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Motive Power Problem under National Administration

The Problem of Motive Power Under the National Administration of Railroads

By Alba B. Johnson
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The Problem of Motive Power Under the National Administration of Railroads

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THE history of railroad development has been one of continuous improvement in size and power of locomotives, and in perfection and economy of details from the beginning of their construction in England and America until the present time. The Rainhill Trials conducted on the Liverpool and Manchester Railway in 1829 demonstrated the practicability of Stephenson's "Rocket," which, in its essentials combined most of the features of present day locomotives. The "Rocket" and "Old Ironsides," Mr. Baldwin's first locomotive, weighed about five tons each, and were scarcely larger than the motor trucks now commonly used on highways.

It would be without the scope of this paper to trace the development of locomotives from "Old Ironsides" of 1832, to the latest triple compound Mallet, or the most approved Decapod of the present day. The eighty-five years which have elapsed since the successful trials of the "John Bull" on the Camden &

Amboy Railroad; the "DeWitt Clinton" on the Mohawk & Hudson Railroad and the "Old Ironsides" on the Philadelphia, Germantown & Norristown Railroad, have been years of constant experiments and improvements, whilst corresponding experiments and improvements have been going on concurrently in the various countries of Europe. Each railway has endeavored to excel others in efficiency and power, and each locomotive builder has striven to excel his competitor.

Viewing the whole progress of locomotive development, one general fact is apparent: in years of excessive business the time and thought of railroad men have been so fully occupied with the movements of traffic as to leave little opportunity for the problems of improving methods and appliances. Waves of depression follow successively waves of expansion, and during years when earnings are small and the necessity for economies is urgent, much attention is concentrated upon problems of improvement. The result has been that each period of business depression has been followed by new developments in the art of transportation. It would not be difficult to trace the periods of minimum traffic which resulted in the changes in track from the 40 to the 60, the 60 to the 80 and the 80 to the 100-lb. rail and now even to the 130-lb. rail; in the car, from the 20 to the 30, the 30 to the 40 and the 40 to the 50 and 70-ton capacity, and now in some cases to the 100-ton capacity; and in the locomotive from the 15" x 24" thirty-ton locomotive of the '70s to the 17" x 24" forty-ton locomotive of the '80s; the 20" x 24" sixty-ton locomotive of the '90s to the 22" x 28" one-hundred-ton locomotive of the first decade of this century; and the further development of the larger types of Mikado, Santa Fe and Mallet—ranging from 300,000 to 500,000 lbs. weight—during the present decade.

The process of development has in each instance been somewhat as follows. It has been found that the readiest means of increasing revenues is to increase the carrying capacity of cars, so that a greater amount of revenue freight can be hauled for each unit of car mileage. The increase in car loading reduced the number of cars which could be hauled per train, and resulted in a demand for larger locomotives capable of hauling no less a number of cars than before. This found its limit in the capacity of rails and bridges to sustain the increased axle loads. Again and again rails and bridges have been replaced to permit of the constantly increasing axle loads from 10 to 15 tons, from 15 to 20, from 20 to 30 and finally to about 35 tons, the present maximum. If we stop to consider for a moment what this has meant to the industry of the country, we will realize that each change has involved practically the total replacement of rails, bridges, cars and locomotives on existing lines throughout the whole country, and each step has resulted in a reduction of the cost per ton mile until the cost of transportation in the United States has gone far below that attained in any other country.

In the majority of instances each contract for cars and locomotives has been made to new specifications, and in comparatively few instances have existing contracts for either cars or locomotives been duplicated without incorporating the changes which have resulted from the combined causes of experience and competition. Standardization has been an ideal much talked of but never realized in actual practice, because standardization implies the crystallization of present practice as the practice of the future, and means that no further changes shall be made as the result of experience or invention. Carried to its logical extreme, the adoption of inflexible standards at any time

during the history of locomotive development would have involved the stoppage of progress at that point. Many attempts have been made to fix standards for particular railroads and groups of roads, but in every instance these have given way to the urgency of keeping pace with other roads which have not attempted to bind themselves with the iron bands of standardization. The practical result of such attempts has been that those lines most rigidly adhering to their standards have lagged behind their competitors.

The result of more than eighty years of experience has convinced railroad men that the most advantageous field for standardization is in details rather than in the complete locomotive or car as a unit. Most of the advantages sought through standardization have been obtained by unifying or standardizing the design of various parts common to a considerable number of classes. Whilst the Railway Master Mechanics' Association and the Master Car Builders' Association have perhaps accomplished less in procuring the adoption of complete standard units than advocates of standardization would have liked to see, they have done splendid service to the transportation interests of the country by the adoption of the numerous standard details, by their discussions and by their interchange of experiences. It may be said that their accomplishments have been as great as it was humanly possible to achieve under the existing conditions of diversity of managements, diversity of ideas and the necessity of constantly keeping abreast of the march of improvement. American railroad men need have no fear of comparison with other countries, either in the practical common sense which has been shown in the conservative encouragement given to improvements in engineering practice, or in the reductions which have been achieved in the cost of transportation. They have been

quick to adapt to American conditions improvements which have been worked out abroad; they have maintained the suitability of American locomotives, not only for American conditions of operating, but they have also maintained the adaptability of American standards for all countries where the conditions approximate to those existing in the United States, thus developing a large foreign trade in railway equipment and materials.

The participation of the United States in the world-war has brought about new conditions. A mass of legislation and regulation which had accumulated during years of peace and which was predicated upon certain popular fears and prejudices resulted in the failure to allow increase in revenues corresponding to increased costs. The necessities of the war soon demonstrated that these regulations which prevented co-operation by insisting upon competition, did not make for efficiency. They prevented many measures of improved service which the railroad managers were themselves eager to adopt but which had been made prohibitive. In order at a single stroke to untangle this situation, the Government of the United States decided that it was wise to assume control of transportation by placing all the principal lines in the control of a Director General of Railways, and to operate the roads as a unit during the period of the war and for a fixed time thereafter. For the first time in the history of the country all of the railroads became subject to a unity of management and to a unity of control in their purchases. For the first time it became practicable to adopt and to enforce standards. To a large extent the very forces of competition had brought about a uniformity of general dimensions and weights of locomotives for trunk line service. Inasmuch as all kinds of cars were being hauled indiscriminately over all railroad lines, there could be no reason why a diversity of details

should exist amongst those belonging to different railroads. To a lesser degree, perhaps, these considerations apply also to motive power. If one type of locomotive could haul a given train across the continent to the west bank of the Mississippi River, there appeared to be no adequate reason why a locomotive of different type or different details should be required to haul the same train from the east bank where the grades and working conditions were not too divergent.

In the early days of railroading it was quite common for the same line to have different types of locomotives to haul its trains over different divisions of the road. The same conditions now exist upon a larger scale. Notwithstanding a certain amount of standardization of the locomotives on each road, there is a large diversity amongst different roads having practically the same operating conditions. The opportunity given to the Director General of Railways to unify the motive power of all railroads, was unique, and the conception a fascinating one. The work of preparing standard specifications and drawings was entrusted to a committee comprising eleven railroad officials who collaborated with representatives of the three principal locomotive builders. As the result of their diligent and continued work, twelve standard specifications have been agreed upon and recommended as follows, and their final approval is now under consideration.

Two sizes of the Mikado type, 2-8-2, based respectively upon 55,000 and 60,000 lbs. per axle. The lighter of these has a weight in working order of 290,000 lbs. and the heavier 325,000 lbs.

Two sizes of Mountain type locomotives, 4-8-2, based respectively upon 55,000 and 60,000 lbs. per axle, the lighter having a total weight in working order of 320,000 lbs. and the heavier of 350,000 lbs.

Two sizes of Pacific type locomotives,

4-6-2, based respectively upon 55,000 and 60,000 lbs. per axle, the former having a weight of 270,000 lbs. and the latter 300,000 lbs. in working order.

Two sizes of Santa Fe type locomotives, 2-10-2, based respectively upon 55,000 and 60,000 lbs. per axle, the lighter having a weight of 360,000 lbs. and the heavier 390,000 lbs. in working order.

A six-wheeled locomotive, 0-6-0, with tender, 55,000 lbs. per axle, weight in working order 165,000 lbs.

An eight-wheeled switching or hump locomotive, 0-8-0, with tender, 55,000 lbs. per axle, 220,000 lbs. weight in working order.

A six-coupled Mallet locomotive with trucks, 2-6-6-2, based upon 60,000 lbs. per axle, weight in working order 440,000 lbs., and

An eight-coupled Mallet locomotive with trucks, 2-8-8-2, based upon 60,000 lbs. per axle and weighing in working order 540,000 lbs.

The tenders have been standardized with tanks of 8,000, 10,000 and 12,000 gallons respectively.

No one railroad will be compelled to order all of these twelve standards; even the largest trunk lines may find half that number sufficient.

A delicate and interesting question of policy is to what degree these standards should be confined to the essential elements of the locomotive, and to what degree they should be extended to its accessories. The committee wisely adopted the principle of defining only the essential locomotive, leaving a certain freedom to the railroads to maintain their standard accessories, and a certain freedom of competition among manufacturers of railway equipment. It must be borne in mind that the railway specialty business itself is a most important one, embodying as it does several hundred separate manufacturers, with invested capital running into the hundreds of millions and employing

several hundred thousand men. These separate manufacturers have studied incessantly to improve their appliances and to reduce costs. Their productions are of two classes, first, those materials or devices which have become essential parts of locomotives, such as air brakes, tires, headlights, injectors, steam gauges, etc., etc.; and second, those which are not strictly essential to locomotive operation but which contribute to efficiency and economy. Amongst the latter are such things as mechanical stokers, superheaters, feed water heaters, power reverse gears, etc. These devices are constantly shifting from the second to the first class. Most of those now universally conceded to be in the first class were at one time probationary. Many of those now rated in the second class are rapidly achieving recognition as essentials to be regarded as in the first class.

To carry standardization to its extreme limit would involve a determination of the most desirable among many competing devices, and would destroy the market for all the others and throw their makers out of business. It would check the transfer into the first class of those items enumerated as of the second class and would also paralyze every effort toward the invention and introduction of new improvements.

The committee has wisely refrained from attempting a solution of these problems, and its further course with respect to them is yet to be ascertained. Some policy must eventually be adopted, however, either of leaving the railroads which are to receive and operate the standard locomotives, latitude to designate such specialties as in their experience have proved worthy of adoption, or for the Director General of Railways, through his advisers, to make a selection. The former would appear to be in every way the wiser course.

I have stated above that the standard specifications have been recommended for ap-

proval. They have not yet been finally adopted, as a strong plea is made on behalf of the railroads similar in principle to that applicable to locomotive accessories, that each railroad should be allowed to continue to adhere to the standards already adopted. The choice of course involves the weighing of the respective advantages. It may be said for the railroads' contention, that under normal conditions locomotives are not shifted from one road to another, but are generally used continuously upon the same division to keep the traffic movement balanced, and are kept in repair continuously by the same shops. These shops are supplied with standard repair parts and the workmen are proficient in maintaining the repairs of these existing standard locomotives. To introduce a new government standard upon all lines as an entirely clean proposition would be simple enough, but to introduce it on lines and conditions affecting an entire continent and already equipped is quite a different problem. It necessarily compels all lines to provide themselves with stores of repair parts adapted to the government standard locomotives. Thus, instead of simplifying the problem of locomotive maintenance, the introduction of government standards would complicate it. These complications would last far beyond the period of government control and would continue as long as the railroad standard and the government standard locomotives operated side by side upon the same lines.

It may be said that the workman who is responsible for the best workmanship, should be entitled to the selection of his own tools, and similarly, that the railroad manager who is responsible for his record of efficiency and economy, should be permitted the widest discretion in selecting locomotives which he regards as best fitted for the conditions of service upon his line. If, however, it should be urged that the advantages of standardization to which the roads can

work, would in the long run be sufficient to compensate for the disadvantages of present increased confusion, then some principle must be discovered by which standardization shall avoid the cessation, if not the extinction of improvements. Every improvement in some sense involves the destruction of standardization. It would be an evil day for American engineering and for American progress in the art of transportation, which would involve a policy of discouragement to new and useful improvements in the art. We should therefore look carefully before we leap, to make sure that we are not giving up the substance of continued growth in efficiency and economy, to grasp the chimera of standardization. Especially should this be considered most carefully when the world-wide danger of this war is upon us.

Any paper upon the subject of railway motive power under the national administration would be incomplete which did not touch upon the remarkable growth and development of electric power transmission in transportation service during recent years. At the Chicago World's Exposition in 1893, the first electric switching locomotive was shown suitable for industrial purposes, and tests were made of its hauling capacity in comparison with a steam switching locomotive of similar weight in which the advantage was shown to be decidedly in favor of the electric locomotive. Shortly thereafter the North American Company caused the construction, under the supervision of Sprague, Duncan & Hutchinson, of an electric locomotive for use on the Northern Pacific Railway; but the failure of the first named Company and the fact that the locomotive was far in advance of the general development of the times, caused its abandonment before it came into practical service.

Shortly after this the Baltimore & Ohio Railroad undertook the construction of its tunnels

under the city of Baltimore and contracted with the General Electric Company for locomotives with large power to handle its trains through these tunnels for the purpose of avoiding smoke and gases. These locomotives proved to be highly successful, but it was several years after their construction before other electric developments succeeded. Meanwhile, however, there had been a continual growth in the adaptation of electric power to interurban trolley lines, to small industrial locomotive units and to mining and other underground problems. Then followed the application of electric power to the Hoosac Tunnel Line; the New York, New Haven & Hartford Line; the West Jersey & Seashore, 65-mile line to Atlantic City from Philadelphia; the Long Island Railroad; and the Grand Trunk Tunnel under the Detroit River. Nearly simultaneously the Norfolk & Western and Chicago, Milwaukee & St. Paul Railways decided upon extensive installations of electric power, both of which are now completed and are showing marked success.

The necessity of avoiding smoke and gases in railway operations in cities soon induced the adoption of electrification for reasons entirely independent of any economies. The elevated lines in New York City were the first and were soon followed by the New York Central and the New Haven Lines, forced thereto by the operation of the tunnels to the Grand Central Station. Then when the Pennsylvania decided upon the construction of its extensive system of tunnels to give a continuous line under and through New York City, the adoption of electric power was unavoidable.

The third cause for the introduction of electric power has been the necessities of suburban traffic in and about New York, Philadelphia and other cities. Practically all these electric railway enterprises have involved different sets of conditions and have resulted

in a study of their peculiar problems which has worked out a motive power well adapted to each case. So large a volume of experience has now been gathered that it may be said that electric transmission of power in railway service has largely passed the experimental stage and the efficiencies predetermined are realized.

The question arises as to what is to be the future relationship between steam and electricity. Doubtless the electrification of suburban lines and the application of electricity to lines having great density of traffic, will be financially justified, and as these grow in number and join themselves together, electric zones will be created in which it will be more economical to adopt electricity exclusively as the motive power.

Any question of rivalry between the steam and electric locomotive may be set aside. The problem is wholly an economic one, the only question being as to which is the more efficient and suitable for the particular conditions, and the consequent adoption of one or the other is dependent upon the geographical or other circumstances governing each case.

The introduction of electric locomotives, by reason of the cost of installation, must be a gradual one. The increase of efficiency and economy must be clearly shown before capital can be induced to make the necessary investment. As these advantages are conclusively shown, so will the development of electrification grow, but it would appear that the great transportation problem of the country as a whole, outside of the larger cities and their suburban territory, must for some time rely upon steam locomotion as its most available and economical motive power.

The motive power of the country is admittedly inadequate to the service demanded of it under the present war conditions. During the depression preceding the war there was a small surplus of power which, as should have

been foreseen, would be absorbed in traffic with the first increase of activity. As a rule, railroads have purchased locomotives largely under the spur of excessive traffic and have abstained from purchasing during periods of reduced earnings. This is contrary to the economics of the situation. Enlargements of facilities should be made in times of depression, because, first, that is the cheapest time to do it; second, it is the most convenient time to do it; and third, it is the time when the managers can give most attention to doing it; and fourth, the employment of labor arising out of large railway purchases tends to mitigate the severity of a general depression. The reason the railroads have not done this since 1907 is, that under the regulatory policy which went into effect at that time, railway managers have not been able to accumulate surpluses sufficient in their judgment to warrant bold construction in times of small earnings, and especially because future earnings have not been susceptible of approximate calculation even where the volume of traffic could be estimated in advance. Adequate provision of motive power, like adequate provision of other rolling-stock and other facilities, can only be assured when Congress places upon the functionary charged with the duty of regulating rates, the definite responsibility of making such rates as will yield earnings sufficient for thorough maintenance, for adequate improvements and sufficient to attract the capital necessary for providing additions and extensions.

The Baldwin Locomotive Works

Record No. 91

Mallet Articulated Locomotives

THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U. S. A.

MALLET ARTICULATED LOCOMOTIVES

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RECORD NO. 91

1918

CODE WORD—REDONNONS

MALLET ARTICULATED LOCOMOTIVE, 2-8-8-2 TYPE. FOR SOUTHERN RAILWAY COMPANY
BALDWIN LOCOMOTIVE No. 50,000

Mallet Articulated Locomotives

THE Mallet type of locomotive was introduced on American railways to meet the demand for a locomotive having exceptionally high tractive force, combined with the ability to readily traverse sharp curves. In order to develop high tractive force, great adhesion weight, and consequently a comparatively large number of driving-wheels, are necessary. If, however, more than five pairs of such wheels must be used, it is not practicable to couple them all in one group, as the rigid wheel-base becomes excessively long, and the reciprocating parts of unwieldy size, owing to the large amount of power which must be transmitted through them. When, therefore, six or more pairs of driving-wheels are required, it is necessary to divide them into at least two groups. Various ways of doing this have been tried; but that devised by Anatole Mallet, a French engineer, and first used by him in Europe in 1889, is the most practical, at least for the high-capacity locomotives that are used on American railways.

The Mallet type employs a single boiler, which is placed over two groups of driving-wheels, each group having its own frames, cylinders and propelling machinery. The frames of the rear group are held in rigid alinement with the boiler, while those of the front group are hinged to the rear frames by means of a pin placed on the center line of the locomotive. The front frames support the forward end of the boiler through sliding bearings, known as waist bearers. When the locomotive enters a curve, the front frames swing about the hinge-pin as a center, the movement being comparable to that of a radial truck. The front boiler bearing is fitted with controlling springs, which tend to hold the front and rear frames in alinement with each other. These springs

assist the rear unit in following the front unit into a curve, and they also aid in restoring the alinement of the front and rear units after the curve has been traversed.

The lower section of each of the waist bearers is fitted with a brass plate, on which the upper section of the bearer slides. The sliding surface is lubricated, and the brass plate takes the wear. The front waist bearer is fitted with clamps, for the purpose of preventing the frames from dropping away in case of derailment, or if it is necessary to handle the assembled boiler and frames with a crane.

The cylinders are arranged on the compound system. Those that drive the rear group of wheels receive steam direct from the boiler, and act as the high-pressure; while the front cylinders receive the high-pressure exhaust, and thus act as the low-pressure. Their exhaust, in turn, is discharged up the stack to create a draught for the fire. The ratio of the cylinder volumes is usually between 2.35 and 2.50. The receiver pipe connecting the high and low-pressure cylinders, and the exhaust pipe connecting the low-pressure cylinders and smokebox, are fitted with flexible joints so that they can accommodate themselves to the swing of the front frames. These pipes, however, carry steam at moderate pressures only; hence no difficulty is experienced in keeping the joints tight.

When possible, the center line of the ball-joint at the back end of the receiver pipe should coincide with the hinge-pin center, so that the pipe is at all times parallel with the front frames. A slip-joint is placed near the front end of the pipe to allow for expansion and contraction. Both joints are fitted with packed glands, so that they can be kept tight and wear can be taken up. The slip-joint in the exhaust pipe is not provided with a gland, but it has a long sliding fit, and water grooves and snap rings are used to prevent leakage. The ball-joint at the back end of this pipe is kept tight by means of a coiled spring, which holds the pipe flange firmly on its seat.

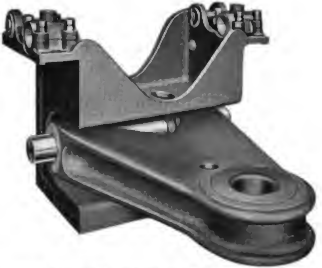
The use of superheated steam in Mallet locomotives, especially of the larger sizes, is practically universal. The superheater itself is arranged as in a single expansion locomotive; but in a Mallet, the high-pressure steam pipes must necessarily extend back from the superheater header in the smokebox, to the high-pressure cylinders. Here the distribution is controlled by piston valves. Either piston or balanced slide valves, the latter pre-

ferably double-ported, may be used on the low-pressure cylinders. A satisfactory method of lubrication is to run one lubricator connection to each high-pressure steam chest, and one to the receiver pipe leading to the low-pressure cylinders. Emergency lubricators are frequently applied to the latter cylinders, but ordinarily their use is not necessary.

With a superheater of correct design and sufficient capacity, initial superheating, before the steam enters the high-pressure cylinders, is all that is required; and reheaters between the high and low-pressure cylinders are no longer being applied.

It is necessary on a Mallet locomotive, to control two sets of valve motion simultaneously, and to do this a power reverse mechanism is required. Such mechanism is usually operated by compressed air, although an auxiliary steam connection can be applied if desired. Another device, which is almost invariably used on large Mallets, is the mechanical stoker; as these locomotives, when working at full capacity, consume more coal than can be fired by hand.

The accompanying drawings show longitudinal and transverse sections of a representative Baldwin Mallet locomotive of the 2-8-8-2 type. Attention may be called, in this connection, to several features of its construction.



FLEXIBLE RADIUS BAR FOR ARTICULATED FRAME CONNECTION

The articulated joint, connecting the front and rear frames, is designed to provide flexibility in a vertical as well as a horizontal plane. The joint is formed by a

tongue, or radius bar, more clearly shown in the illustration on page 5, which is attached at its forward end to a horizontal pin, and at its rear end to a vertical pin. The horizontal pin is supported by a steel casting, which forms a strong transverse brace at the rear end of the front frames. The vertical pin is placed on the center line of the locomotive, in a pocket formed in the high-pressure cylinder saddle. This pin fits into a spherical bushing which, in turn, is fitted into the end of the radius bar. The construction is plainly shown in the illustrations. When the locomotive passes over uneven tracks or sudden changes in grade, the frames can, with this arrangement, have a vertical movement relative to each other, without causing binding at the articulated joint. The frames are neither interlocked in any way, nor connected by hanger bolts.

The high-pressure cylinders are cast separate from their saddle. The saddle is of cast steel, made in two pieces, the upper one of which is riveted to the boiler shell. Large bearing areas are provided between the cylinders, frames and saddle to insure an amply strong construction and prevent the parts from working loose in service. The front frames are stopped just back of the low-pressure cylinders, and are here bolted and keyed to a steel casting to which, in turn, the cylinders are attached. The steel casting is provided with suitable lugs, which support the fulcrum pin of the forward equalizing beam; and to this casting the front foot-plate is bolted.

A special feature of the machinery is the reach-rod connecting the reverse shafts of the front and back engines. This reach-rod is placed on the center line of the locomotive, and is provided with a flexible joint, which slides on guides secured to the inner walls of the high-pressure cylinder saddle. The flexible joint is placed immediately above the articulated frame connection. With this arrangement, there is practically no distortion to the movement of the low-pressure valves when the locomotive is traversing curves.

It is essential in a Mallet locomotive, that means be provided for admitting steam direct from the boiler to the low-pressure cylinders when starting, so that full tractive force can be developed. In the Baldwin Mallet this is done either by admitting steam to the receiver pipe through a manually controlled valve in the cab, or else by using an automatic valve, which is placed in a pipe connecting one of the high-pressure steam pipes with the receiver pipe. With the latter arrangement,

the valve in the pipe connection closes as soon as the receiver pipe pressure builds up on account of the high-pressure exhaust. The locomotive then works compound entirely.

Mallet locomotives are frequently equipped with an arrangement of intercepting and reducing valves, which permits the locomotive to be worked single expansion, if desired. When so working, the high-pressure cylinders exhaust directly up the stack instead of into the receiver pipe, and the low-pressure cylinders receive live steam at reduced pressure, which is admitted to the receiver pipe through the reducing valve.

Apart from its size, the boiler of a large Mallet locomotive is generally similar to that of a single expansion locomotive. In large Mallet boilers it is customary to use combustion chambers. This has the double advantage of increasing the firebox volume and heating surface, and of keeping the length of the tubes within the limits of good practice. Liners are riveted to the boiler shell above the waist bearers and high-pressure cylinder saddle. It is the most recent practice of The Baldwin Locomotive Works to place these liners outside the shell, in order to facilitate caulking.

The under side of the smokebox in large Mallet boilers, is frequently flattened, in order to provide sufficient clearance for the exhaust pipe, and for the front cylinders and valve motion when the locomotive is traversing curves.

The Handling of Mallet Articulated Locomotives

Although a Mallet locomotive develops approximately twice the tractive force of a single expansion locomotive having half the number of driving-wheels and the same load per axle, there is nothing mysterious or specially difficult about the handling or maintenance of this type. A Mallet locomotive really consists of two single expansion engines placed under one boiler, and it is therefore free of those features which, in some other types of compound locomotives, have been the cause of annoyance and expense.

Before taking the locomotive from the round-house, it is important that the air pressure be fully pumped up, so that the power reverse gear is operative; and that all the sandboxes are filled, so that sand can be delivered to either the front or back group of wheels, or to both, as required. Until the cylinders are thoroughly warmed up, the cylinder cocks should be kept open, as there is

liable to be considerable condensation, especially in the low-pressure cylinders.

If the locomotive is coupled to the head end of its train, and is equipped with a manually controlled starting valve, a start can usually be made without opening this valve, provided slack can be taken up. If, however, the locomotive is pushing a train up a grade, or if it is impossible to take up the slack, the starting valve should be opened, and closed again as soon as the low-pressure cylinders are exhausting up the stack. Nothing will be gained in the way of hauling capacity by opening the starting valve after the train is moving.

If the locomotive is equipped with intercepting and reducing valves and an auxiliary high-pressure exhaust to the stack, it can be thrown into single expansion working, should there be danger of stalling on a grade. In all cases, however, the locomotive should, if possible, be worked compound, as a material reduction in fuel and water consumption is secured thereby.

The flexible pipes which convey the steam from the high to the low-pressure cylinders, and from the latter to the smokebox, should frequently be inspected and tested for leakage; as it is important that the ball and slip-joints be kept tight. The sliding bearings supporting the boiler on the front frames should be regularly oiled; also the hinge-pin connecting the front and rear frames, and the joint in the reach-rod connecting the front and back reverse shafts.

Under normal conditions, with valves, pistons and pipe connections steam-tight, little difficulty will be experienced on account of slipping of the driving-wheels. If the low-pressure engine slips frequently, while the high-pressure does not, it is an indication that live steam is leaking past the high-pressure pistons or valves, and these parts should be examined for blows. Ordinarily, if the high-pressure engine slips, the receiver pressure builds up and the resulting back pressure tends to stop the slipping; while if the low-pressure engine slips, the receiver pressure at once drops, and the slipping ceases. Any continuous slipping can occur only on the part of both engines simultaneously, and can be corrected by throttling the steam supply and using sand.

Care should be taken not to work the engine at too short a cut-off, as this will result in excessive compression and hard riding. If too much power is still being developed after the engine is linked up to the shortest practicable cut-off, the throttle should be partly closed.

The following instructions as to how to test for

blows, and what to do in the event of breakdowns on Mallet locomotives, are based on information given in "Locomotive Running and Management," by Angus Sinclair.

To test for blows, proceed as follows:—

Low-pressure valve—Place the engine on either quarter on the side to be tested, with the reverse lever in the center of the quadrant, and open the low-pressure cylinder cocks. If the locomotive has a manually controlled starting valve, open it; if an automatic valve, open the main throttle. If steam escapes from either cylinder cock, it indicates a blow in the valve.

High-pressure valve—Place the engine on either quarter on the side to be tested, with the reverse lever in the center of the quadrant, and open the high-pressure cylinder cocks and main throttle. If steam escapes from either cylinder cock, it indicates a blow in the valve.

Low-pressure piston packing—Place the engine on either quarter on the side to be tested, open the cylinder cocks, set the driving brakes, and place the reverse lever in full gear, either forward or backward. If the locomotive has a manually controlled starting valve, open it; if an automatic valve, open the main throttle. If steam escapes from both cylinder cocks, the piston packing is defective.

High-pressure piston packing—The test is similar to that just described, except that the main throttle must be opened in all cases.

To test for a broken low-pressure valve or seat—Proceed as when testing for a blowing valve, except that after the valve has been tested with the reverse lever in the center of the quadrant, the lever should be moved first to the forward end and then to the back end of the quadrant. A loud blow at the stack, with the reverse lever at either end of the quadrant, but not in both positions, would indicate a broken valve or a broken bridge. If there is a blow at the stack with the reverse lever at both the forward and back ends of the quadrant, it is probably due to broken piston packing.

To test for a broken high-pressure valve or seat—Proceed as in the previous test, except that in all cases the main throttle should be opened; while if there is a separate exhaust from the high-pressure cylinder to the stack, that should be opened also, and the broken valve or seat can then be detected by a steady blow up the stack. If the engine has no auxiliary exhaust for the high-pressure cylinder, the steam which blows past the

broken high-pressure valve will flow into the receiver pipe and thence to the low-pressure cylinders, and can be detected when it escapes at the low-pressure cylinder cocks or relief valves, if the locomotive is equipped with such valves.

In general, broken valves or packing rings in the low-pressure cylinders of a Mallet locomotive decrease the power of the engine to a greater extent than if similar parts are broken in the high-pressure cylinders.

If the low-pressure cylinders are equipped with by-pass valves, and there are indications that these are stuck or broken, proceed as follows:—Place the engine on either the top or bottom quarter, and the reverse lever in full gear, either front or back. If the locomotive has a manually controlled starting valve, open it; if an automatic valve, open the main throttle. This will admit steam to one end of the low-pressure cylinder. If the by-pass valve at that end is broken, or stuck in the open position, it will allow steam to pass through to the other end of the cylinder, and thence out through the exhaust, creating a blow at the stack. A stuck or broken by-pass valve will also create a blow instead of a normal exhaust, when the locomotive is running; while if both valves on one side are stuck or broken, there will be a continuous blow. If the valve is simply stuck, it can often be made to act freely by taking off the valve cap, and cleaning and lubricating it thoroughly. If broken, it can sometimes be blocked to its seat, or a blind gasket put in between the by-pass valve chamber and the port communicating with the live-steam port.

If a piston, either high or low-pressure, were to break, the front cylinder head should be taken off, the broken parts removed, and the valve on that side disconnected and clamped in its middle position. The locomotive can then be run, and the piston oiled, if necessary, through the open end of the cylinder.

If a cylinder or cylinder head, either high or low-pressure, were to break, the valve on that side should be disconnected and clamped in its middle position. If the cylinder is so badly broken that it is unsafe to allow the piston to move back and forth in it, the main rod should also be taken down before proceeding.

If a frame on the forward engine breaks through both upper and lower rails, between the cylinder and main driving pedestals, the valve on that side should be disconnected and clamped in its middle position, and the locomotive could then proceed, using three cylinders and handling reduced tonnage. If both rails were broken

between the main and rear driving pedestals, the back sections of both side rods should be taken down before proceeding.

If one of the frames of the rear engine breaks through both rails, it is preferable, in all cases, to cut out the cylinder on that side by clamping the valve in its middle position. If the break occurs just back of the cylinders, so that a pull on the frame would be liable to tear off the guides and their attachments, the locomotive should be run in light. If the break is back of the guide yoke, the locomotive can proceed with about half its tonnage, using three cylinders.

If the reach-rod connecting the front and back reverse shafts breaks, the broken parts should either be removed or securely tied up, and the link blocks of the forward engine blocked up to a point where the locomotive could easily handle the train.

If the reach-rod connecting the power reverse with the back reverse shaft were to break, it would be necessary to block the link blocks on both the front and rear engines before proceeding.

If any parts of the valve gear break, temporary repairs can be made in exactly the same manner as on a single expansion locomotive using the same type of gear.

Tractive Force of Mallet Articulated Locomotives

Various formulas are in use for calculating the tractive force of Mallet locomotives, and it is frequently a question as to which of these is the most accurate. In discussing these formulas, the following symbols are used:—

Let C = diameter of high-pressure cylinders in inches.
c = diameter of low-pressure cylinders in inches.
S = stroke of piston in inches.
P = boiler pressure in pounds per square inch.
H = maximum mean effective pressure in high-pressure cylinders, in pounds per square inch.
E = maximum mean effective pressure in low-pressure cylinders, in pounds per square inch.
D = diameter of driving-wheels in inches.
R = ratio of cylinder volumes.
T = total tractive force in pounds.
K = a constant.

The formulas in most general use are as follows:—

The Baldwin Locomotive Works. Two formulas are given in "Locomotive Data," as follows:—

$$T = \frac{C^2 \times S \times 1.2\ P}{D}$$

for cylinder ratios of approximately 2.35 to 2.40; and

$$T = \frac{c^2 \times S \times 1.7\ P}{(R + 1) \times D}$$

for varying cylinder ratios.

American Locomotive Co. The Locomotive Hand-Book, published by this Company, contains the following formula:—

$$T = \frac{c^2 \times S \times K \times P}{D}$$

Values of K, for different cylinder ratios, are given on page 15 of the Hand-Book.

George R. Henderson. The following formula is given in "Locomotive Operation" (1904), page 372:—

$$T = \frac{c^2 \times S \times 1.6\ P}{(R + 1) \times D}$$

Interstate Commerce Commission. Circular No. 22, issued November 3, 1915, gives this formula for two-cylinder compounds:—

$$T = \frac{2/3\ C^2 \times S \times P}{D}$$

Applied to Mallet locomotives, this formula becomes

$$T = \frac{1.33\ C^2 \times S \times P}{D}$$

COMPARISON. The foregoing formulas are all based upon the same general formula for receiver compound locomotives having such valve settings that the power is equally divided between the high and low-pressure cylinders. On this assumption, the mean effective pressures of the two cylinders are inversely proportional to the squares of their diameters, or to the cylinder ratio. Hence

$$\frac{H}{E} = \frac{c^2}{C^2}$$

Assuming for the moment a total mean effective pressure equal to the boiler pressure, we have

$$P - E = H$$

Substituting

$$\frac{P - E}{E} = \frac{c^2}{C^2} = R, \text{ therefore } E = \frac{P}{R + 1}$$

If T_l equals the tractive force developed by the low-pressure cylinders, we have, according to the usual formula,

$$T_l = \frac{c^2 \times S \times E}{D}$$

Substituting the value of E given above, this becomes

$$T_l = \frac{c^2 \times S \times P}{(R + 1) \times D} \qquad \text{(a)}$$

Applying this to Mallet locomotives on the assumption that equal power is developed in the high and low-pressure cylinders, and that the total mean effective

pressure is 85 per cent of the boiler pressure, the formula becomes:—

$$T = 2 \times \frac{c^2 \times S \times .85\ P}{(R + 1) \times D} = \frac{c^2 \times S \times 1.7\ P}{(R + 1) \times D} \quad \text{(b)}$$

If calculated on the basis of the high-pressure cylinder, this formula becomes

$$T = 2 \times \frac{C^2 \times S \times .85\ P \times R}{(R + 1) \times D}$$

which for a cylinder ratio of 2.4 becomes

$$T = \frac{C^2 \times S \times 1.2\ P}{D} \quad \text{(c)}$$

Formulas (b) and (c) are those used by The Baldwin Locomotive Works.

For full tractive force, the formula of the American Locomotive Co. uses a value of .52 for K, with a cylinder ratio of 2.5. Substituting these values, and modifying the formula in accordance with formula (a), we have

$$T = \frac{c^2 \times S \times .52\ P}{D} = 2 \times \frac{c^2 \times S \times .91\ P}{D \times 3.5}$$

showing that the formula is based on a mean effective pressure equal to .91 boiler pressure.

The formula of G. R. Henderson is based on a mean effective pressure equal to 80 per cent of the boiler pressure. It was proposed at a time when superheated steam was not used and when valve settings were different from those now employed. The factor is somewhat low for modern Mallets.

Circular No. 22 of the Insterstate Commerce Commission gives three formulas, viz: One for single expansion locomotives based on a mean effective pressure of 85 per cent boiler pressure; one for four cylinder locomotives, which is the formula used by The Baldwin Locomotive Works for Vauclain and tandem compounds, and is not applicable to Mallets; and one for two cylinder compounds, having valve settings which differ from those used on modern Mallets. If the expression for tractive force in this formula be multiplied by two, we have

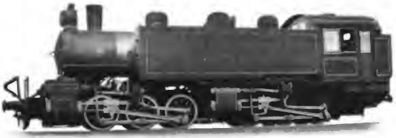
$$T = \frac{1.33\ C^2 \times S \times P}{D}$$

or in terms of the low-pressure cylinder, for a ratio of 2.4,

$$T = 2 \times \frac{c^2 \times S \times .94\ P}{(R + 1) \times D}$$

so that the tractive force is based upon a mean effective pressure equal to 94 per cent of the boiler pressure.

Formula (b) is the official formula of The Baldwin Locomotive Works, and it has been recommended to both the Interstate Commerce Commission and the United States Railroad Administration. It has been used in all cases for calculating the tractive forces of the locomotives described in this pamphlet.



Minas y Ferro-Carril de Utrillas, Spain

This locomotive uses saturated steam and exerts a tractive force of 33,200 pounds. It is operating on rails weighing 66 pounds per yard, and on grades of 3 per cent. The runs are comparatively short, and a separate tender is not required. The fuel and water used are of poor quality, and the boiler has a wide firebox with comparatively large grate area. The frames are of the plate type, and those of the rear engine are placed outside the wheels, in order to provide adequate support for the firebox and to insure sufficient stability. A flexible design of articulated frame connection, as described on page 5, is used on this locomotive. The running gear throughout is built for severe service on rough tracks. The equipment includes screw couplers with spring buffers, and combined hand and English automatic vacuum brakes.

Mallet Articulated Locomotive, 0-6-6-0 Type

Baldwin Class 12-11-DD, 19 | for the | Gauge 3′ 4″

Minas y Ferro-Carril de Utrillas, Spain

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	16″
Diameter, L. P.	25″
Stroke	22″
Valves—H. P., Type	Piston, 8″ diam.
Maximum travel	5″
Steam lap	1 1/8″
Exhaust clearance	1/4″
Lead	1/4″
Valves—L. P., Type	Balanced slide
Maximum travel	4 1/2″
Steam lap	5/8″
Exhaust clearance	3/8″
Lead	3/16″

BOILER

Type	Straight
Diameter at front end	50″
Thickness of barrel sheets	1/2″
Working pressure	200 lbs.
Fuel	Lignite

Firebox—Staying	Radial
Length	96″
Width	53″
Depth, front	51 1/4″
Depth, back	48 3/4″
Thickness of sheets (copper)—	
Sides	1/2″
Back	1/2″
Crown	1/2″
Tube	3/4″ and 1/2″
Water space—Front	3″
Sides	3″
Back	2 1/2″
Tubes—Diameter	2″
Material	Steel
Thickness	No. 12 W. G.
Number	152
Length	15′ 6″
Heating Surface—Firebox	109 sq. ft.
Tubes	1227 sq. ft.
Total	1336 sq. ft.
Grate area	35.3 sq. ft.

DRIVING-WHEELS

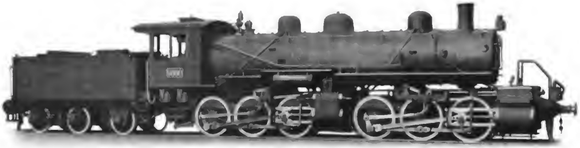
Diameter, outside	41″
Diameter, center	36″
Journals	7″ x 8″

WHEEL-BASE, ETC.

Driving	23′ 6″
Rigid	8′ 0″
Total engine	23′ 6″
Length over all	37′ 7 3/4″
Width over all	9′ 2″
Height over all	12′ 4 1/2″
Height, rail to center of boiler	7′ 6″

WEIGHT

On driving-wheels	165,200 lbs.
Total engine	165,200 lbs.
Tank capacity	2245 U. S. gals.
Fuel capacity	2 tons



Imperial Government Railways of Japan

Eighteen locomotives of the design illustrated have been built for the Imperial Government Railways. They are operating on curves of 400 feet radius, and grades of 1 in 30. The tractive force developed is 30,300 pounds. A large amount of foreign material was used in their construction. A strict weight limit was specified, and the detail parts are as light as is consistent with the strength required. Heat-treated steel is used for the crank-pins, driving and tender-axles, and driving-wheel and tender-wheel tires. The driving-axles are hollow-bored. The boiler is fitted with a fire-tube superheater, and the firebox contains a brick arch supported on studs. Automatic vacuum brake equipment is applied, and the driving-brakes can also be operated by means of a hand-wheel and screw. The tender is carried on six wheels, one pair being held in rigid pedestals, while the other two pairs are held in a center-bearing, arch-bar truck.

Mallet Articulated Locomotive, 0-6-6-0 Type

Baldwin Class 12-$\frac{22}{44}$-DD, 1 for the Gauge 3' 6"

Imperial Government Railways of Japan

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	16"
Diameter, L. P.	25"
Stroke	24"
Valves—H. P., Type	Piston, 9" diam.
Maximum travel	5"
Steam lap	1⅛"
Exhaust clearance	¼"
Lead	¼"
Valves—L. P., Type	Balanced slide
Maximum travel	4½"
Steam lap	⅞"
Exhaust clearance	⅜"
Lead	⅛"

BOILER

Type	Straight
Diameter at front end	58"
Thickness of barrel sheets	⅝"
Working pressure	200 lbs.
Fuel	Soft coal

Firebox—Staying	Radial
Length	102⅝"
Width	29⅞"
Depth, front	62"
Depth, back	50½"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	½"
Water space—Front	3½"
Sides	2½"
Back	3"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 8 W. G. 2¼", No. 12 W. G.
Number	5½", 16; 2¼", 101
Length	16' 4"
Heating Surface—Firebox	122 sq. ft.
Tubes	1341 sq. ft.
Total	1463 sq. ft.
Superheating surface	323 sq. ft.
Grate area	21.2 sq. ft.

DRIVING-WHEELS

Diameter, outside	49"
Diameter, center	43"
Journals	7" x 8"

WHEEL-BASE, ETC.

Driving	26' 2"
Rigid	9' 0"
Total engine	26' 2"
Total engine and tender	48' 0"
Length over all	57' 7¾"
Width over all	8' 4"
Height over all	12' 7½"
Height, rail to center of boiler	7' 8½"

WEIGHT

On driving-wheels	142,650 lbs.
Total engine	142,650 lbs.
Total engine and tender	205,000 lbs.

TENDER

Wheels, number	6
Wheels, diameter	37"
Journals	5½" x 9"
Tank capacity	3240 U. S. gals.
Fuel capacity	3 tons

Arica La Paz Railway, Chile

Three locomotives of this design are operating in freight service at an altitude of 14,000 feet, where excessively cold weather is experienced. They were designed with a limiting weight of 12 metric tons (26,450 pounds) per pair of driving-wheels, and exert a tractive force of 31,300 pounds. A superheater is applied, and the firebox, which is built of copper plates, is of the Gaines type. The front part of the firebox is used as a combustion chamber, and is separated from the rear part by a bridge wall and arch. The water space stays are of copper. An indication of the severe conditions under which these locomotives work, is found in the fact that the pilot at the front end, and the rail guard at the rear of the tender, have exceptionally strong bracing, in order to knock off any rocks which may happen to fall on the track.

Mallet Articulated Locomotive, 0-6-6-0 Type

Baldwin Class 12-[illegible]-DD, 23

for the

Arica La Paz Railway, Chile

Gauge 3′ $3\frac{3}{8}$″

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	16″
Diameter, L. P.	25″
Stroke	22″
Valves—H. P., Type	Piston, 9″ diam.
Maximum travel	5″
Steam lap	$1\frac{1}{8}$″
Exhaust clearance	$\frac{1}{4}$″
Lead	$\frac{1}{4}$″
Valves—L. P., Type	Piston, 11″ diam.
Maximum travel	5″
Steam lap	$\frac{9}{16}$″
Exhaust clearance	$\frac{1}{4}$″
Lead	$\frac{5}{16}$″

BOILER

Type—Straight top with Gaines locomotive furnace	
Diameter at front end	56″
Thickness of barrel sheets	$\frac{1}{2}$″
Working pressure	200 lbs.
Fuel	Soft coal

FIREBOX—Staying	Radial
Length, total	$102\frac{1}{2}$″
Length of grate	81″
Width	56″
Depth, front	$50\frac{1}{2}$″
Depth, back	$47\frac{1}{2}$″
Thickness of sheets (copper)—	
Sides	$\frac{1}{2}$″
Back	$\frac{1}{2}$″
Crown	$\frac{5}{8}$″
Tube	$\frac{3}{4}$″ and $\frac{1}{2}$″
Water space—Front	4″
Sides	3″
Back	3″
TUBES—Diameter	$5\frac{3}{8}$″ and 2″
Material	Steel
Thickness	$5\frac{3}{8}$″, No. 9 W. G. 2″, No. 12 W. G.
Number	$5\frac{3}{8}$″, 18; 2″, 105
Length	16′ 10″
HEATING SURFACE—Firebox	118 sq. ft.
Tubes	1345 sq. ft.
Firebrick tubes	16 sq. ft.
Total	1479 sq. ft.
Superheating surface	363 sq. ft.
Grate area	31.3 sq. ft.

DRIVING-WHEELS

Diameter, outside	$43\frac{1}{2}$″
Diameter, center	$37\frac{1}{2}$″
Journals, main	$7\frac{1}{2}$″ x 8″
Journals, others	7″ x 8″

WHEEL-BASE, ETC.

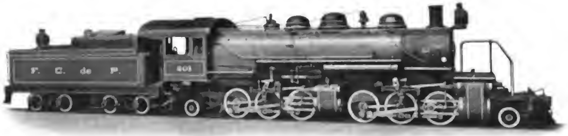
Driving	24′ 5″
Rigid	8′ 6″
Total engine	24′ 5″
Total engine and tender	50′ $4\frac{1}{2}$″
Length over all	63′ $6\frac{5}{8}$″
Width over all	8′ 7″
Height over all	12′ $3\frac{1}{2}$″
Height, rail to center of boiler	7′ 6″

WEIGHT (Estimated)

On driving-wheels	150,000 lbs.
Total engine	150,000 lbs.
Total engine and tender	230,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	30″
Journals	$4\frac{1}{4}$″ x 8″
Tank capacity	4000 U. S. gals.
Fuel capacity	6 tons



Andes Copper Mining Company, Chile

This locomotive operates at maximum altitudes of 12,000 feet and traverses curves of 280 feet radius. It was designed with a limiting weight of 22,000 pounds per pair of driving-wheels. The fuel used is California residual oil. The Baldwin arrangement of flexible articulated frame connection, as described on page 5, is used in this design. A single bearer, placed between the second and third pairs of driving-wheels, supports the boiler over the front frames; and this bearer is fitted with the controlling spring. The equipment includes automatic couplers, and combined automatic and straight air-brakes. The short rigid wheel-base of this locomotive, with a radial truck at each end, fits it for service where curves are frequent, and where a large amount of backing up is necessary.

Mallet Articulated Locomotive, 2-6-6-2 Type

Baldwin Class 16-[illegible]-¼-DD, 8 for the Gauge 3′ 3⅜″

Andes Copper Mining Company, Chile

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	16″
Diameter, L. P.	25″
Stroke	20″
Valves—H. P., Type	9″ piston
Maximum travel	5″
Steam lap	1⅛″
Exhaust clearance	¼″
Lead	¼″
Valves—L. P., Type	11″ piston
Maximum travel	4½″
Steam lap	⅝″
Exhaust clearance	⅜″
Lead	5/16″

BOILER

Type	Straight
Diameter at front end	58″
Thickness of barrel sheets	⅝″
Working pressure	200 lbs.
Fuel	Oil
Firebox—Staying	Radial
Length	86 3/16″
Width	52⅝″
Firebox—Continued	
Depth, front	54″
Depth, back	51½″
Thickness of sheets—Sides	⅜″
Back	⅝″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″
Tubes—Diameter	5⅜″ and 2″
Material	5⅜″, steel; 2″, iron
Thickness	5⅜″, No. 9 W. G. 2″, No. 12 W. G.
Number	5⅜″, 16; 2″, 121
Length	17′ 0″
Heating Surface—Firebox	113 sq. ft.
Tubes	1453 sq. ft.
Total	1566 sq. ft.
Superheating surface	311 sq. ft.
Grate area	31.5 sq. ft.

DRIVING-WHEELS

Diameter, outside	42″
Diameter, center	36″
Journals, main	7½″ x 8″
Journals, others	7″ x 8″

TRUCK-WHEELS

Diameter, front	24¼″
Journals	4″ x 6½″
Diameter, back	24¼″
Journals	4″ x 6½″

WHEEL-BASE, ETC.

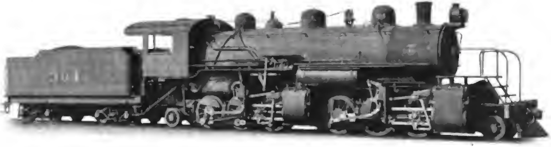
Driving	23′ 2″
Rigid	8′ 0″
Total engine	36′ 0″
Total engine and tender	60′ 2″
Length over all	69′ 10½″
Width over all	8′ 2″
Height over all	12′ 5″
Height, rail to center of boiler	7′ 7½″

WEIGHT

On driving-wheels	130,950 lbs.
On truck, front	12,750 lbs.
On truck, back	13,400 lbs.
Total engine	157,100 lbs.
Total engine and tender	238,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	28″
Journals	4¼″ x 8″
Tank capacity, water	4000 U. S. gals.
Tank capacity, oil	1800 U. S. gals.



Missouri, Oklahoma & Gulf Railway Company

Mallet locomotives, under favorable conditions, are specially suitable for heavy service on lines where wheel loads are limited on account of comparatively light tracks and bridges. The locomotive illustrated was designed for service on rails weighing 70 pounds per yard, and develops a tractive force of 60,000 pounds. Approximately 88 per cent of the total weight is carried on the driving-wheels. With a rigid wheel-base of only 9 feet 10 inches, the hauling capacity of this locomotive is equal to that of a Consolidation or Mikado type locomotive designed for service on 100-pound rails. The front and rear trucks are of the radial type; they carry comparatively light wheel loads, and the locomotive curves easily and can be safely run in either direction. The boiler contains a superheater, and is of ample capacity for heavy service.

Mallet Articulated Locomotive, 2-6-6-2 Type

Baldwin Class 16-[illegible]-¼-DD, 5 — for the — Gauge 4' 8½"

Missouri, Oklahoma & Gulf Railway Company

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	21"
Diameter, L. P.	32"
Stroke	30"
Valves—H. P., Type	Piston, 13" diam.
Maximum travel	5½"
Steam lap	1¼"
Exhaust clearance	5/16"
Lead	¼"
Valves—L. P., Type	Piston, 13" diam.
Maximum travel	6"
Steam lap	1"
Exhaust clearance	3/16"
Lead	3/16"

BOILER

Type	Straight
Diameter at front end	74"
Thickness of barrel sheets	25/32" and 13/16"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	116⅛"
Width	66¼"
Firebox—Continued	
Depth, front	72½"
Depth, back	65"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	½"
Water space—Front	5"
Sides	5"
Back	5"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 9 W. G.
	2¼", No. 11 W. G.
Number	5½", 26; 2¼", 191
Length	21' 0"
Heating Surface—Firebox	198 sq. ft.
Tubes	3209 sq. ft.
Total	3407 sq. ft.
Superheating surface	685 sq. ft.
Grate area	53.4 sq. ft.

DRIVING-WHEELS

Diameter, outside	55"
Diameter, center	48"
Journals	9½" x 12"

TRUCK-WHEELS

Diameter, front	31"
Journals	6" x 12"
Diameter, back	31"
Journals	6" x 12"

WHEEL-BASE, ETC.

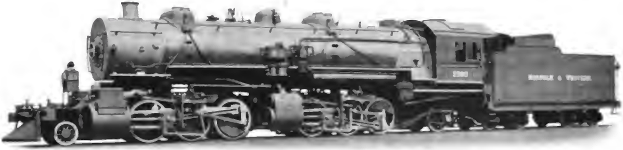
Driving	28' 11"
Rigid	9' 10"
Total engine	43' 9"
Total engine and tender	72' 8½"
Length over all	81' 7¾"
Width over all	10' 6"
Height over all	15' 7"
Height, rail to center of boiler	9' 9"

WEIGHT

On driving-wheels	277,100 lbs.
On truck, front	21,100 lbs.
On truck, back	17,600 lbs.
Total engine	315,800 lbs.
Total engine and tender	470,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	13 tons



Norfolk & Western Railway Company

Locomotives of this design have proved specially successful in heavy road service on the Norfolk and Western Ry. With a rigid wheel-base of only 10 feet, they develop a tractive force of 67,500 pounds, and have ample steaming capacity for sustained, heavy hauling. The firebox contains a brick arch, and has a combustion chamber 78 inches long, thus providing large furnace volume. A mechanical stoker is applied. Superheated steam is distributed to the high-pressure cylinders by piston valves and to the low-pressure by double-ported, balanced slide valves. The locomotive is equipped with intercepting and reducing valves, and with an auxiliary high-pressure exhaust to the stack, so that, if necessary, it can be worked single expansion.

These locomotives were built in accordance with drawings and specifications furnished by the Railway Company.

Mallet Articulated Locomotive, 2-6-6-2 Type

Baldwin Class 16-[illegible]-¼-DD, 1
Railway Co's Class Z-1-A

for the

Norfolk & Western Railway Company

Gauge 4' 8½"

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	22"
Diameter, L. P.	35"
Stroke	32"
Valves—H. P., Type	Piston, 12" diam.
Maximum travel	6½"
Steam lap	7/8"
Exhaust clearance	¼"
Lead	¼"
Valves—L. P., Type	Balanced slide
Maximum travel	5½"
Steam lap	1⅛"
Exhaust clearance	⅜"
Lead	⅛"

BOILER

Type	Conical
Diameter at front end	83⅞"
Thickness of barrel sheets	13/16" and 1"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	108⅛"
Width	96⅛"
Depth, front	88½"
Depth, back	70½"

Firebox—Continued	
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	9/16"
Water space—Front	5"
Sides	4½"
Back	4½"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 9 W. G. 2¼", 0.110"
Number	5½", 36; 2¼", 224
Length	24' 0"
Heating Surface—Firebox	212 sq. ft.
Combustion chamber	134 sq. ft.
Tubes	4396 sq. ft.
Firebrick tubes	29 sq. ft.
Total	4771 sq. ft.
Superheating surface	1022 sq. ft.
Grate area	72 sq. ft.

DRIVING-WHEELS

Diameter, outside	56"
Diameter, center	50"
Journals	10" x 12"

TRUCK-WHEELS

Diameter, front	30"
Journals	6" x 10"
Diameter, back	44"
Journals	8" x 14"

WHEEL-BASE, ETC.

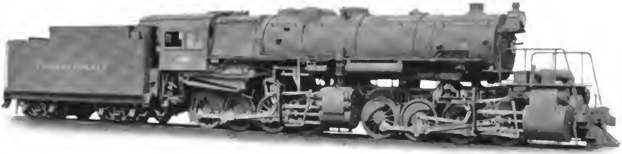
Driving	30' 6"
Rigid	10' 0"
Total engine	48' 10"
Total engine and tender	79' 2½"
Length over all	88' 1½"
Width over all	10' 8"
Height over all	15' 6"
Height, rail to center of boiler	10' 0¼"

WEIGHT

On driving-wheels	341,000 lbs.
On truck, front	22,200 lbs.
On truck, back	48,500 lbs.
Total engine	411,700 lbs.
Total engine and tender	571,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	9000 U. S. gals.
Fuel capacity	14 tons



The Pennsylvania Railroad Company

This locomotive was specially designed for heavy freight and pushing service on maximum grades of 2.1 per cent and curves of 16 degrees. It develops a tractive force of 82,800 pounds. The boiler, in accordance with Pennsylvania Railroad practice, has a firebox of the Belpaire type. A superheater and brick arch are applied. The steam distribution to all the cylinders is controlled by double-ported piston valves. The machinery and running gear details are designed, to a large extent, in conformity with Pennsylvania Railroad standard practice. Heat-treated steel is used for the piston-rods, main crank-pins and main driving-axles. The second and third pairs of wheels in each group are fitted with plain tires.

With the 0-8-8-0 wheel arrangement, the entire weight of the locomotive is available for adhesion. This general design is, therefore, specially suitable for heavy pushing or hump-yard service, where maximum hauling capacity in proportion to locomotive weight is desired.

Mallet Articulated Locomotive, 0-8-8-0 Type

for

The Pennsylvania Railroad Company

Baldwin Class 16-[illegible]-EE, 1
Railroad Co's Class CC-1-S

Gauge 4′ 8½″

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	25″
Diameter, L. P.	39″
Stroke	30″
Valves—H. P., Type	Piston, 14″ diam.
Maximum travel	5½″
Steam lap	1⅛″
Exhaust clearance	⅛″
Lead	¼″
Valves—L. P., Type	Piston, 14″ diam.
Maximum travel	6″
Steam lap	⅞″
Exhaust clearance	¼″
Lead	¼″

BOILER

Type	Straight Belpaire
Diameter at front end	84″
Thickness of barrel sheets	⅞″
Working pressure	205 lbs.
Fuel	Soft coal

Firebox—Staying	Vertical
Length	117″
Width	96″
Depth, front	84″
Depth, back	61″
Thickness of sheets—Sides	5/16″
Back	⅜″
Crown	⅜″
Tube	½″
Water space—Front	5″
Sides	5″
Back	5″
Tubes—Diameter	5½″ and 2¼″
Material	Steel
Thickness	5½″, No. 9 W. G. 2¼″, No. 11 W. G.
Number	5½″, 36; 2¼″, 259
Length	23′ 0″
Heating Surface—Firebox	220 sq. ft.
Tubes	4684 sq. ft.
Firebrick tubes	32 sq. ft.
Total	4936 sq. ft.
Superheating surface	1020 sq. ft.
Grate area	78 sq. ft.

DRIVING-WHEELS

Diameter, outside	56″
Diameter, center	50″
Journals, main	10½″ x 13″
Journals, others	9½″ x 13″

WHEEL-BASE, ETC.

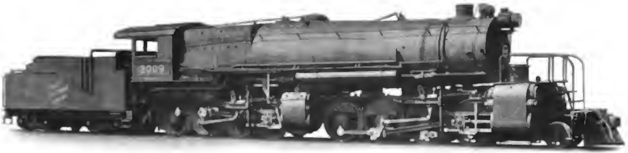
Driving	39′ 6″
Rigid	15′ 0″
Total engine	39′ 6″
Total engine and tender	71′ 8¾″
Length over all	87′ 6¾″
Width over all	10′ 8″
Height over all	15′ 3″
Height, rail to center of boiler	10′ 6″

WEIGHT

On driving-wheels	408,700 lbs.
Total engine	408,700 lbs.
Total engine and tender	580,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33″
Journals	6″ x 11″
Tank capacity	9000 U. S. gals.
Fuel capacity	35,000 lbs.



Great Northern Railway Company

The Great Northern was the first railway in the United States to adopt Mallet locomotives on a large scale, and to demonstrate the advantages of the type in heavy road as well as pushing service. The first Mallets built for this line were completed by The Baldwin Locomotive Works in 1906; they were of the 2-6-6-2 type, and exerted a tractive force of 64,500 pounds. The locomotive illustrated, which is one of a group of twenty-five, develops a tractive force of 98,500 pounds, and as it is specially designed for road service it has a truck at the front end only. In accordance with Great Northern practice, these locomotives have boilers of the Belpaire type, and Emerson superheaters. A number are equipped for using oil as fuel. The low-pressure piston valves are double-ported. By means of a simple arrangement controlled by a hand-wheel in the cab, the cut-off in the low-pressure cylinders can be varied independently of that in the high-pressure, to suit the conditions under which the locomotive is working.

Mallet Articulated Locomotive, 2-8-8-0 Type

Baldwin Class 18-44/88-EE, 10
Railway Co's Class N-1

for the
Great Northern Railway Company

Gauge 4' 8½"

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	28"
Diameter, L. P.	42"
Stroke	32"
Valves—H. P., Type	Piston, 15" diam.
Maximum travel	6½"
Steam lap	1⅝"
Exhaust clearance	⅜"
Lead	¼"
Valves—L. P., Type	Piston, 15" diam.
Maximum travel	7½"
Steam lap	1⅜"
Exhaust clearance	⅜"
Lead	⅜"

BOILER

Type	Conical Belpaire
Diameter at front end	90"
Thickness of barrel sheets	⅝" and 1"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	117¼"
Width	96¼"
Firebox—Continued	
Depth, front	87¼"
Depth, back	76¼"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	⅝"
Water space—Front	6"
Sides	5"
Back	5"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 8 W. G. 2¼", No. 11 W. G.
Number	5½", 42; 2¼", 332
Length	24' 0"
Heating Surface—Firebox	245 sq. ft.
Combustion chamber	81 sq. ft.
Tubes	6120 sq. ft.
Total	6446 sq. ft.
Superheating surface	1368 sq. ft.
Grate area	78.4 sq. ft.

DRIVING-WHEELS

Diameter, outside	63"
Diameter, center	56"
Journals, main	11" x 12"
Journals, others	10" x 12"

TRUCK-WHEELS

Diameter	33½"
Journals	6" x 12"

WHEEL-BASE, ETC.

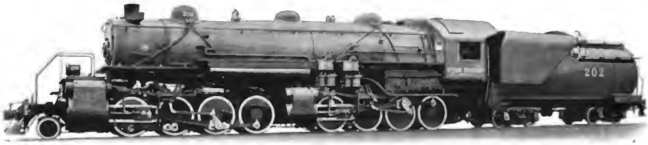
Driving	43' 3"
Rigid	16' 6"
Total engine	52' 6"
Total engine and tender	83' 1"
Length over all	95' 1½"
Width over all	11' 1"
Height over all	16' 0"
Height, rail to center of boiler	10' 6"

WEIGHT (Estimated)

On driving-wheels	420,000 lbs.
On truck	30,000 lbs.
Total engine	450,000 lbs.
Total engine and tender	600,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	13 tons



Utah Railway Company

This locomotive operates in road and pushing service on grades of 2.4 per cent. There are curves of 9 degrees on the main line, and of 20 degrees on sidings. The tractive force exerted is 96,800 pounds. The locomotive is equipped with an intercepting and a reducing valve, and the high-pressure cylinders have an auxiliary exhaust to the stack. The low-pressure piston valves are double-ported. Heat-treated steel is used for the piston-rods, crank-pins and driving-axles; and the main frames are of vanadium steel. The articulated frame connection is of the Baldwin flexible type. A mechanical stoker is applied, and the firebox has a combustion chamber and brick arch. The equipment includes flange lubricators on the front and rear driving-wheels of each group.

With 95 per cent of its total weight on driving-wheels, this locomotive is admirably fitted for heavy, slow-speed service on steep grades.

Mallet Articulated Locomotive, 2-8-8-0 Type

Baldwin Class 18-48-EE, 48

for the

Utah Railway Company

Gauge 4′ 8½″

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	26″
Diameter, L. P.	41″
Stroke	32″
Valves—H. P., Type	Piston, 15″ diam.
Maximum travel	6½″
Steam lap	1⅝″
Exhaust clearance	⅜″
Lead	¼″
Valves—L. P., Type	Piston, 15″diam.
Maximum travel	7½″
Steam lap	1⅜″
Exhaust clearance	⅜″
Lead	⅜″

BOILER

Type	Conical
Diameter at front end	90″
Thickness of barrel sheets,	⅞″, 1″ and 1⅛″
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	132⅛″
Width	96″
Firebox—Continued	
Depth, front	80¾″
Depth, back	69″
Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	⅜″
Tube	½″
Water space—Front	6″
Sides	5″
Back	5″
Tubes—Diameter	5½″ and 2¼″
Material	5½″, steel; 2¼″, iron
Thickness	5½″, 0.150″ 2¼″, 0.125″
Number	5½″, 48; 2¼″, 269
Length	24′ 0″
Heating Surface—Firebox	231 sq. ft.
Combustion chamber	118 sq. ft.
Tubes	5443 sq. ft.
Firebrick tubes	43 sq. ft.
Total	5835 sq. ft.
Superheating surface	1446 sq. ft.
Grate area	88.2 sq. ft.

DRIVING-WHEELS

Diameter, outside	57″
Diameter, center	50″
Journals, main	10½″ x 20″
Journals, others	10″ x 12″

TRUCK-WHEELS

Diameter	30″
Journals	6½″ x 14″

WHEEL-BASE, ETC.

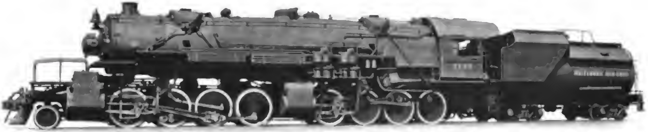
Driving	41′ 2″
Rigid	15′ 6″
Total engine	50′ 4″
Total engine and tender	88′ 6″
Length over all	98′ 7″
Width over all	11′ 0″
Height over all	15′ 10″
Height, rail to center of boiler	10′ 2½″

WEIGHT

On driving-wheels	452,300 lbs.
On truck	24,000 lbs.
Total engine	476,300 lbs.
Total engine and tender	692,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33″
Journals	6½″ x 12″
Tank capacity	12,000 U. S. gals.
Fuel capacity	20 tons



The Baltimore & Ohio Railroad Company

In the year 1916, The Baldwin Locomotive Works built fifteen Mallets of the 2-8-8-0 type for the Baltimore & Ohio R. R. These locomotives were specially designed for road service on the Cumberland Division, where a heavy coal traffic is handled over maximum grades of 2.4 per cent. Working compound, the tractive force developed, calculated from the formula used by The Baldwin Locomotive Works, is 95,000 pounds. The illustration shows one of thirty additional locomotives of the same type, which were subsequently ordered. These locomotives are designed to traverse curves of 22 degrees. They are equipped with superheaters, combustion chambers and brick arches, and are fired with mechanical stokers. The low-pressure steam distribution is controlled by Allen double-ported balanced slide valves. Further details include the Baldwin automatic starting valve, and the flexible design of articulated frame connection, as described on page 5.

Mallet Articulated Locomotive, 2-8-8-0 Type

for

The Baltimore & Ohio Railroad Company

Baldwin Class 18-41-EE, 36
Railroad Co's Class EL-3

Gauge 4' 8½"

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	26"
Diameter, L. P.	41"
Stroke	32"
Valves—H. P., Type	Piston, 14" diam.
Maximum travel	6"
Steam lap	⅞"
Exhaust clearance	5/16"
Lead	3/16"
Valves—L. P., Type	Allen balanced slide
Maximum travel	5½"
Steam lap	1"
Exhaust clearance	3/16"
Lead	3/16"

BOILER

Type	Conical
Diameter at front end	90"
Thickness of barrel sheets	⅝", 1", 1 1/16"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	132⅛"
Width	96"

Firebox—Continued	
Depth, front	89¼"
Depth, back	67"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	½"
Water space—Front	6"
Sides	6" to 4"
Back	4"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 9 W. G. 2¼", 0.125"
Number	5½", 48; 2¼", 269
Length	24' 0"
Heating Surface—Firebox	228 sq. ft.
Combustion chamber	113 sq. ft.
Tubes	5443 sq. ft.
Firebrick tubes	35 sq. ft.
Total	5819 sq. ft.
Superheating surface	1415 sq. ft.
Grate area	88.2 sq. ft.

DRIVING-WHEELS

Diameter, outside	58"
Diameter, center	50"
Journals, main	10½" x 20"
Journals, others	10" x 13"

TRUCK-WHEELS

Diameter	33"
Journals	6" x 10"

WHEEL-BASE, ETC.

Driving	41' 2"
Rigid	15' 6"
Total engine	50' 4"
Total engine and tender	87' 5¼"
Length over all	98' 0½"
Width over all	11' 4"
Height over all	15' 6"
Height, rail to center of boiler	10' 1"

WEIGHT

On driving-wheels	459,400 lbs.
On truck	25,000 lbs.
Total engine	484,400 lbs.
Total engine and tender	694,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	12,000 U. S. gals.
Fuel capacity	20 tons

Southern Railway Company

Twelve locomotives, as illustrated, have been built for the Southern Railway System. The wheel loading is suitable for rails weighing 80 pounds and over per yard. These locomotives are designed for road service; they traverse curves of 16 degrees, and develop a tractive force of 84,800 pounds. Flanged tires are used on all the wheels, and flange lubricators are applied to the leading driving-wheels of each group. The boiler contains a superheater, and is fired with a mechanical stoker. The firebox has a combustion chamber 59 inches long, with a brick wall built across the throat of the chamber, to baffle the gases. The locomotive is equipped with intercepting and reducing valves, and also with a high-pressure auxiliary exhaust to the stack. The frames, in accordance with the practice of this railway, are of vanadium steel; and the articulated frame connection is of the Baldwin flexible type.

The locomotive illustrated is the fifty-thousandth locomotive built by The Baldwin Locomotive Works.

Mallet Articulated Locomotive, 2-8-8-2 Type

for the

Southern Railway Company

Baldwin Class 20-44-¼-EE, 6
Railway Co's Class L^{Sl}-56-$^{23}\frac{4}{10}$^{30}-84.3

Gauge 4' 8½"

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	25"
Diameter, L. P.	39"
Stroke	30"
Valves—H. P., Type	Piston, 14" diam.
Maximum travel	6"
Steam lap	1⅛"
Exhaust clearance	⅜"
Lead	¼"
Valves—L. P., Type	Piston, 14" diam.
Maximum travel	6¼"
Steam lap	⅞"
Exhaust clearance	¼"
Lead	¼"

BOILER

Type	Conical
Diameter at front end	80"
Thickness of barrel sheets	13/16", ⅞", 23/32"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	132¼"
Width	90¼"

Firebox—Continued	
Depth, front	85½"
Depth, back	69"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	⅝"
Water space—Front	6"
Sides	5"
Back	5"
Tubes—Diameter	5½" and 2¼"
Material	5½", steel; 2¼", iron
Thickness	5½", No. 9 W. G. 2¼", No. 11 W. G.
Number	5½", 42; 2¼", 228
Length	24' 0"
Heating Surface—Firebox	226 sq. ft.
Combustion chamber	109 sq. ft.
Tubes	4658 sq. ft.
Total	4993 sq. ft.
Superheating surface	1260 sq. ft.
Grate area	83 sq. ft.

DRIVING-WHEELS

Diameter, outside	56"
Diameter, center	50"
Journals, main	10" x 22"
Journals, others	9½" x 12"

TRUCK-WHEELS

Diameter, front	33"
Journals	6" x 12"
Diameter, back	33"
Journals	6" x 12"

WHEEL-BASE, ETC.

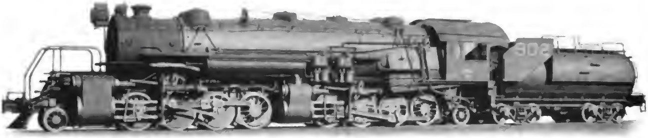
Driving	41' 1"
Rigid	15' 6"
Total engine	56' 3"
Total engine and tender	86' 10¾"
Length over all	96' 0"
Width over all	11' 1½"
Height over all	15' 6"
Height, rail to center of boiler	10' 0"

WEIGHT

On driving-wheels	374,000 lbs.
On truck, front	27,300 lbs.
On truck, back	25,700 lbs.
Total engine	427,000 lbs.
Total engine and tender	603,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	12 tons



Nashville, Chattanooga & St. Louis Railway Company

This locomotive is one of three which were specially designed for operating on 2 per cent grades. Previous to the introduction of the Mallets, a full tonnage train was handled on these grades by three locomotives. The largest road engines on the line are of the Mikado type; and each Mallet, with a tractive force of 97,000 pounds, replaces two Mikados in heavy pushing service. The Mallets were designed to traverse curves of 339 feet radius, and to turn on 90-foot turntables. The boiler contains a combustion chamber, arch and superheater, and is fired with a mechanical stoker. The articulated frame connection is of the flexible type, as described on page 5. The 2-8-8-2 wheel arrangement is specially suitable for a locomotive which, like this one, is used in mountain service and must frequently back down grades.

Mallet Articulated Locomotive, 2-8-8-2 Type

Baldwin Class 20-48-¼-EE, 3 — for the — Gauge 4′ 8½″
Railway Co's Class M-1-99

Nashville, Chattanooga and St. Louis Railway Company

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	27″
Diameter, L. P.	41″
Stroke	30″
Valves—H. P., Type	Piston, 15″ diam.
Maximum travel	6¾″
Steam lap	1⅝″
Exhaust clearance	⅜″
Lead	5/16″
Valves—L. P., Type	Piston, 15″ diam.
Maximum travel	7½″
Steam lap	1⅜″
Exhaust clearance	⅜″
Lead	¼″

BOILER

Type	Conical
Diameter at front end	88″
Thickness of barrel sheets	⅞″, 15/16″ and 1″
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	126″
Width	97¾″
Depth, front	83″
Depth, back	68″
Firebox—Continued	
Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	⅜″
Tube	½″
Water space—Front	5″
Sides	5″
Back	5″
Tubes—Diameter	5½″ and 2¼″
Material	Steel
Thickness	5½″, No. 9 W. G. 2¼″, No. 11 W. G.
Number	5½″, 43; 2¼″, 253
Length	24′ 0″
Heating Surface—Firebox	228 sq. ft.
Combustion chamber	116 sq. ft.
Tubes	5044 sq. ft.
Firebrick tubes	45 sq. ft.
Total	5433 sq. ft.
Superheating surface	1262 sq. ft.
Grate area	85.5 sq. ft.

DRIVING-WHEELS

Diameter, outside	56″
Diameter, center	50″
Journals, main	11″ x 12″
Journals, others	9½″ x 12″

TRUCK-WHEELS

Diameter, front	33″
Journals	5½″ x 12″
Diameter, back	33″
Journals	5½″ x 12″

WHEEL-BASE, ETC.

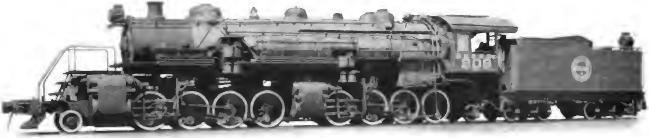
Driving	40′ 4″
Rigid	15′ 0″
Total engine	55′ 8″
Total engine and tender	85′ 7¾″
Length over all	97′ 7″
Width over all	11′ 2″
Height over all	15′ 6″
Height, rail to center of boiler	10′ 2″

WEIGHT

On driving-wheels	430,300 lbs.
On truck, front	20,100 lbs.
On truck, back	19,000 lbs.
Total engine	469,400 lbs.
Total engine and tender	635,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	36″
Journals	5½″ x 10″
Tank capacity	8500 U. S. gals.
Fuel capacity	14 tons



Duluth, Missabe & Northern Railway Company

Since 1910 this road has been using Baldwin Mallet type locomotives between the ore docks at Duluth and the yards at Proctor, a distance of seven miles. For six miles there is an ascending grade of 2.2 per cent, combined with numerous compensated curves of 6 to 10 degrees. The Mallets haul empty ore cars up the grade and bring loaded cars down. They are operated in either direction without turning, and for such service the 2-8-8-2 wheel arrangement is specially suitable. The locomotive illustrated develops a tractive force of 90,700 pounds, and is of the same hauling capacity as those built in 1910; but the design has been thoroughly revised throughout. This locomotive is equipped with a superheater, brick arch and mechanical stoker, and it is shown in the drawings placed opposite page 4. These drawings fully illustrate the principal constructive details.

Mallet Articulated Locomotive, 2-8-8-2 Type

Baldwin Class 20-44-¼-EE, 72 — for the — Gauge 4' 8½"

Railway Co's Class M-1

Duluth, Missabe & Northern Railway Company

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	26"
Diameter, L. P.	40"
Stroke	32"
Valves—H. P., Type	Piston, 15" diam.
Maximum travel	6"
Steam lap	1⅜"
Exhaust clearance	¼"
Lead	¼"
Valves—L. P., Type	Piston, 15" diam.
Maximum travel	7"
Steam lap	1 5/16"
Exhaust clearance	3/16"
Lead	¼"

BOILER

Type	Conical
Diameter at front end	86"
Thickness of barrel sheets	⅞", ⅞", ⅝"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	126"
Width	96"
Depth, front	89"
Depth, back	67½"

Firebox—Continued	
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	½"
Water space—Front	6"
Sides	5"
Back	5"
Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 9 W. G. 2¼", No. 11 W. G.
Number	5½", 43; 2¼", 253
Length	24' 0"
Heating Surface—Firebox	223 sq. ft.
Combustion chamber	108 sq. ft.
Tubes	5045 sq. ft.
Firebrick tubes	48 sq. ft.
Total	5424 sq. ft.
Superheating surface	1168 sq. ft.
Grate area	84 sq. ft.

DRIVING-WHEELS

Diameter, outside	57"
Diameter, center	50"
Journals, main	11" x 12"
Journals, others	10½" x 12"

TRUCK-WHEELS

Diameter, front	30"
Journals	6" x 11"
Diameter, back	30"
Journals	6" x 11"

WHEEL-BASE, ETC.

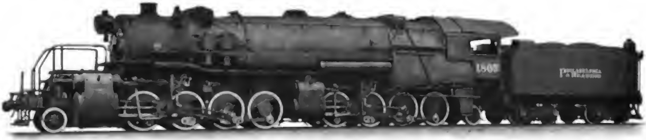
Driving	40' 3"
Rigid	15' 0"
Total engine	55' 9"
Total engine and tender	83' 6½"
Length over all	95' 7¼"
Width over all	11' 0"
Height over all	15' 10½"
Height, rail to center of boiler	10' 2"

WEIGHT

On driving-wheels	415,200 lbs.
On truck, front	28,300 lbs.
On truck, back	26,700 lbs.
Total engine	470,200 lbs.
Total engine and tender	647,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	16 tons



Philadelphia & Reading Railway Company

The locomotive illustrated is one of six which were specially designed for heavy freight and pushing service on 3 per cent grades. These locomotives proved so successful, that additional engines of the same class were subsequently ordered. The tractive force exerted is 98,000 pounds. The boiler is of the Wootten type, designed to burn a mixture of fine anthracite and bituminous coal. A superheater and mechanical stoker are applied. The firebox has a combustion chamber 46 inches long, and a brick wall is built across the throat of the chamber. Owing to restricted clearance limits it was necessary, in this case, to place the boiler at a comparatively low elevation, thus crowding the machinery and running gear; and considering these limitations, the locomotive is of unusually high capacity. The articulated frame connection is of the Baldwin flexible type. Where practicable, detail parts of the Mallets interchange with those of the Mikado type locomotives in service on this road.

Mallet Articulated Locomotive, 2-8-8-2 Type

Baldwin Class 20-44-¼-EE, 79
Railway Co's Class N-1-a

for the

Philadelphia & Reading Railway Company

Gauge 4′ 8½″

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P.	26″
Diameter, L. P.	40″
Stroke	32″
Valves—H. P., Type	Piston, 14 diam.
Maximum travel	6″
Steam lap	1⅛″
Exhaust clearance	⅜″
Lead	¼″
Valves—L. P., Type	Piston, 14″ diam.
Maximum travel	6¼″
Steam lap	⅞″
Exhaust clearance	¼″
Lead	¼″

BOILER

Type	Conical Wootten
Diameter at front end	90″
Thickness of barrel sheets	⅞″ and 1″
Working pressure	210 lbs.
Fuel	Hard and soft coal mixed
Firebox—Staying	Radial
Length	144¼″
Width	108¼″
Depth, front	84½″
Depth, back	65½″

Firebox—Continued

Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	⅜″
Tube	⅝″
Water space—Front	5″
Sides	4″
Back	4″
Tubes—Diameter	5½″ and 2¼″
Material	5½″, steel; 2¼″, iron
Thickness	5½″, No. 9 W. G. 2¼″, No. 11 W. G.
Number	5½″, 50; 2¼″, 277
Length	23′ 0″
Heating Surface—Firebox	264 sq. ft.
Combustion chamber	94 sq. ft.
Tubes	5389 sq. ft.
Total	5747 sq. ft.
Superheating surface	1436 sq. ft.
Grate area	108 sq. ft.

DRIVING-WHEELS

Diameter, outside	55½″
Diameter, center	49″
Journals	11″ x 13″

TRUCK-WHEELS

Diameter, front	33″
Journals	7″ x 11″
Diameter, back	33″
Journals	7″ x 11″

WHEEL-BASE, ETC.

Driving	39′ 8″
Rigid	15′ 0″
Total engine	55′ 10″
Total engine and tender	82′ 11½″
Length over all	91′ 8½″
Width over all	10′ 8″
Height over all	15′ 0″
Height, rail to center of boiler	9′ 9″

WEIGHT

On driving-wheels	435,200 lbs.
On truck, front	23,000 lbs.
On truck, back	20,300 lbs.
Total engine	478,500 lbs.
Total engine and tender	630,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	36″
Journals	6″ x 11″
Tank capacity	8000 U. S. gals.
Fuel capacity	13 tons

Erie Railroad Company

The triple locomotive, illustrated above, is a development of the Mallet articulated type, and is specially designed for heavy pushing service. Driving-wheels are placed under the tender, so that the weight of the latter is utilized for adhesion. The cylinders driving the middle group of wheels receive steam direct from the boiler, and exhaust into the front and rear cylinders simultaneously. All the cylinders are cast from the same pattern, and the ratio of compounding is as one to two. The three sets of valve motions are operated by a power reverse gear. The front low-pressure cylinders exhaust up the stack, thus creating a draught for the fire; while the exhaust from the rear cylinders, after passing through a feed water heater, escapes up a pipe at the rear end of the tank. The locomotive is equipped with a superheater, arch and mechanical stoker, and develops a tractive force of 160,000 pounds.

Three locomotives of this design are in pushing service on a heavy grade near Susquehanna, Penna.

Triple Articulated Locomotive, 2-8-8-8-2 Type

Baldwin Class 28-66-66-66-¼-EEE, 3
Railroad Co's Class P-1

for the
Erie Railroad Company

Gauge 4' 8½"

GENERAL DIMENSIONS

CYLINDERS

Diameter, H. P. (2)	36"
Diameter, L. P. (4)	36"
Stroke	32"
Valves—H. P. Type	Piston, 16" diam.
Maximum travel	6½"
Steam lap	1"
Exhaust clearance	½"
Lead	⅜"
Valves—L. P., Type	Piston, 16" diam.
Maximum travel	F., 5½"; B., 6"
Steam lap*	F., 1½"; B., 1¾"
Exhaust clearance	¼"
Lead	⅜"

BOILER

Type	Conical
Diameter at front end	94"
Thickness of barrel sheets	⅞" and 1"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	162"
Width	108"

FIREBOX—Continued

Depth, front	87¼"
Depth, back	65¾"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	⅝"
Water space—Front	6"
Sides	5"
Back	5"

TUBES

Tubes—Diameter	5½" and 2¼"
Material	Steel
Thickness	5½", No. 9. W. G., 2¼", No. 11 W. G.
Number	5½", 53; 2¼", 326
Length	24' 0"

HEATING SURFACE

Heating Surface—Firebox	251 sq. ft.
Combustion chamber	108 sq. ft.
Tubes	6418 sq. ft.
Firebrick tubes	74 sq. ft.
Total	6851 sq. ft.
Superheating surface	1584 sq. ft.
Grate area	121.5 sq. ft.

DRIVING-WHEELS

Diameter, outside	63"
Diameter, center	56"
Journals	11" x 13½"

TRUCK-WHEELS

Diameter, front	33"
Journals	6" x 12"
Diameter, back	42"
Journals	9" x 14"

WHEEL-BASE, ETC.

Driving	71' 6"
Rigid	16' 6"
Total	91' 0"
Length over all	106' 0"
Width over all	11' 3"
Height over all	16' 4"
Height, rail to center of boiler	10' 7"

WEIGHT (Estimated)

On driving wheels	766,300 lbs.
On truck, front	32,050 lbs.
On truck, back	62,000 lbs.
Total	860,350 lbs.
Tank capacity	11,600 U. S. gals.
Fuel capacity	16 tons

* The valve travels and steam laps of the front and back low-pressure valves are different.

GENERAL OFFICES OF THE COMPANY

500 North Broad Street, Philadelphia

REPRESENTATIVES AND AGENTS

New York, N. Y.	F. W. Weston	120 Broadway
Chicago, Ill.	C. H. Peterson	627 Railway Exchange
St. Louis, Mo.	A. S. Goble	1210 Boatmen's Bank Building
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THE BALDWIN LOCOMOTIVE WORKS

THE FIFTY THOUSANDTH LOCOMOTIVE

RECORD Nº 92

THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U. S. A.

THE FIFTY-THOUSANDTH LOCOMOTIVE

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RECORD No. 92

1918

Code Word—REDORMIR

THE BALDWIN LOCOMOTIVE WORKS, EDDYSTONE PLANT

BALDWIN LOCOMOTIVE NUMBER FIFTY-THOUSAND

BUILT FOR THE

SOUTHERN RAILWAY COMPANY

AFTER eighty-seven years of continuous operation, The Baldwin Locomotive Works has completed its fifty-thousandth locomotive. During all these years, the principal plant of the Company has been located in the City of Philadelphia. Originally established in 1831, this plant has, at least in part, occupied its present site since 1835. The principles and policies of its founder, Matthias W. Baldwin, have continued as a dominating influence down to the present time; and when, in 1911, the old partnership which had owned and operated the works until then was discontinued, and the present company was incorporated, there was no material change in the organization or personnel.

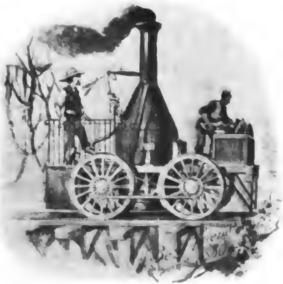
Locomotive number Fifty-thousand is one of a group of twelve built for the Southern Railway Co., and is of the Mallet articulated type, with 2-8-8-2 wheel arrangement. Before describing it, some facts regarding the Southern Railway System, and a brief review of the motive power built by The Baldwin Locomotive Works for this road, may prove of interest.

The story of the Southern Railway System goes back to the very beginning of railroad construction in the United States. While the Baltimore & Ohio was

slowly extending its line from Baltimore in 1828, the construction of the railroad from Charleston, South Carolina, to Hamburg on the Savannah River opposite Augusta, Georgia, was commenced, and when this road of 136 miles was completed and put in operation on October 1, 1833, it enjoyed the distinction of being the longest railroad in the world. The story of this pioneer railroad is especially interesting because, with the exception of the "Tom Thumb," (an experimental locomotive built by Peter Cooper), the first locomotive built in America was operated on its rails. Until the Rainhill test in England there had been doubts as to the economic practicability of the steam locomotive. The Baltimore & Ohio was still using horses at this time and attaining the then extraordinary speed of 15 miles an hour, and during this period sails as a motive power were being tried on the short length of the Charleston & Hamburg line, which had been completed. In January, 1830, Horatio Allen, who had studied railroads in England, was appointed Chief Engineer of the Charleston & Hamburg Railroad. He immediately recommended to the Board of Directors that the locomotive be adopted as the sole motive power, saying, "there was no reason to expect any material improvement in the breed of horses, but the man was not living who knew what the breed of locomotives was to place at command."

In his book, "When Railroads Were New," Charles Frederick Carter says:

"Having determined to use steam, the directors of the Charleston & Hamburg Railroad lost no time in authorizing the construction of the first locomotive ever built in America for regular service. It was a fearful and wonderful contrivance, designed by E. L. Miller, of Charleston. The vertical boiler looked something like an overgrown porter bottle of the old style. The firebox had 'teats' radiating from its outer wall to afford additional heating surface. The four



THE "BEST FRIEND"
(From an Illustration in "The World's Railway," by J. G. Pangborn)

wheels had iron hubs and tires and wooden spokes and felloes. The two cylinders, six inches in diameter by sixteen inches stroke, placed in front of the boiler, worked cranks inside the frame. The engine, which was christened the 'Best Friend of Charleston,' was built at the West Point Foundry in New York."

The trial trip was made on November 2, 1830. The wheels proved to be so weak that one of them sprung out of shape and threw the engine into the ditch on the return trip. A second trip was made on December 14, and a third on the following day, when the Best Friend proved to possess power double the contract requirements. This pioneer engine was able to make sixteen to twenty-one miles an hour with forty or fifty passengers in four or five cars, and to attain a speed of thirty-five miles an hour without cars.

The success of the Charleston & Hamburg Railroad was followed by the projection and construction of railroads throughout the South, including many lines

destined afterwards to be incorporated in the Southern Railway System. The war between the States found the South relatively as well supplied with railroads as any other part of the country. During the war the railroads of the South were alternately used and destroyed, first by one belligerent and then the other, and were left physical wrecks in a section without money and without credit. The work of reconstruction was courageously undertaken. Then followed years of receiverships and reorganization in which there was a constant tendency in the direction of the consolidation of short local lines into efficient through systems. Two of the systems thus evolved were the Richmond & Danville and the East Tennessee, Virginia & Georgia. These were together controlled by the Richmond Terminal Company, which failed disasterously in 1892.

The late J. P. Morgan undertook and carried through a reorganization, which resulted in the organization of the Southern Railway Company in 1894. The new Company began business on July 1 in that year, operating 2012 miles of railroad, which was increased during the first year to 4392 miles.

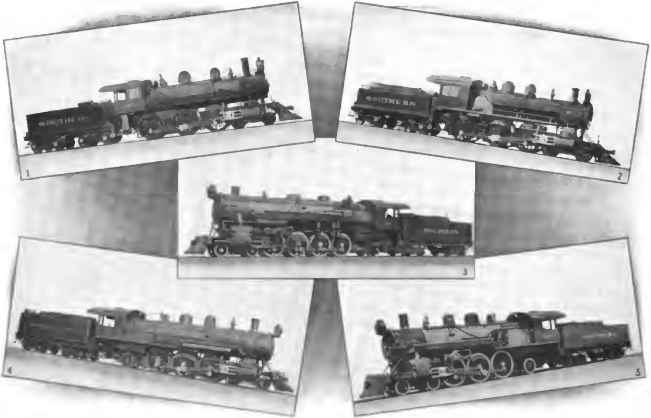
From the beginning the geographical policy of the Company was well defined and strictly adhered to. It was that of providing a system under a single management that would serve the entire territory south of the Ohio and Potomac Rivers, with lines to the ports and to the principal crossings of the Mississippi River from St. Louis to New Orleans.

At the end of the last fiscal year, June 30, 1917, the total operated mileage of the System, inclusive of mileage owned and operated independently, was 7922. Except for a few short pieces of double-track at terminals the Southern Railway, during the first year of its operation (1894) was altogether a single-track system. It has today 916 miles of double-track. At the end of the first fiscal year the System had 623 locomotives,

487 passenger train cars, 18,924 freight train cars and 283 road service cars. It now has 2210 locomotives, 1432 passenger train cars, 70,012 freight train cars and 2518 road service cars. These figures by no means reflect the full increase in the capacity of the Southern Railway System's equipment since the end of its first fiscal year. The heaviest locomotive then in service weighed less than 75 tons, while locomotive number Fifty-thousand weighs 213 tons. The average tractive power of locomotives has been increased more than 50 per cent. The carrying capacity of coal cars has been doubled, and the carrying capacity of the standard system box car is more than 30 per cent greater than in the first year.

From the first the Southern Railway System has been a most efficient agency in the development of the South, co-operating with the communities along its lines for the enlargement of their agricultural and industrial production. It has given the South a transportation service of constantly increasing efficiency, and the result is reflected in the traffic statistics and gross earnings of the System. During its first fiscal year the System's earnings from operation were \$17,114,791.69, or \$8,506.36 per mile. During its last year, earnings from operation were \$116,942,262.18, or \$14,761.71 per mile.

The policy of the Southern has always been to use heavy locomotives; and the size and capacity of the motive power units have been increased as rapidly as the increased strength of tracks and bridges would permit. The first locomotives built for the newly organized company by the Baldwin Locomotive Works were of the ten-wheeled type, for passenger service, and were completed in 1897-1898. One of them was exhibited at the Tennessee Centennial and International Exposition. These locomotives had cylinders measuring 21 by 28 inches, and driving-wheels 72 inches in diameter. They weighed, in working order, 154,400



PASSENGER LOCOMOTIVES BUILT FOR THE SOUTHERN RY.

1. Ten-wheeled Locomotive with Narrow Firebox
2. Ten-wheeled Locomotive with Wide Firebox
3. Mountain Type Locomotive
4. Pacific Type Locomotive using Saturated Steam
5. Pacific Type Locomotive using Superheated Steam

FREIGHT LOCOMOTIVES BUILT FOR THE SOUTHERN RY.

1. Consolidation Type Locomotive with Narrow Firebox 2. Consolidation Type Locomotive with Wide Firebox
4. Mikado Type Locomotive 3. Mallet Articulated Locomotive, 2-6-8-0 Type 5. Santa Fe Type Locomotive

pounds, and were among the heaviest passenger locomotives in use at the time of their construction.

Heavy freight traffic at this time, 1898, was handled by locomotives of the Consolidation type, a number of which were built by the Baldwin Locomotive Works. These also had 21 by 28 inch cylinders. The driving-wheels were 58 inches in diameter, and the total weight in working order was 152,000 pounds.

Wide fireboxes were first applied to Baldwin locomotives for the Southern Railway in 1902, when they were used on a number of ten-wheeled locomotives designed for heavy passenger service. These locomotives had the same sized cylinders and driving-wheels as those built in 1897, but with larger boilers the total weight was increased to 170,920 pounds. In 1903, freight locomotives of the Consolidation type, with wide fireboxes, were built. They had the same sized cylinders as the passenger locomotives, but were immediately followed by a new design of Consolidation, in which the size of the cylinders was increased to 22 by 30 inches, with a total weight of 193,760 pounds.

The Southern was among the first railways in the United States to recognize the advantages of the Pacific (4-6-2) type for heavy passenger service. In 1903 the road received from the Baldwin Locomotive Works, five Pacific type locomotives, which were the first of a long series of successful locomotives of this type built for the Southern Railway and its controlled lines. These locomotives had cylinders measuring 22 by 28 inches and driving-wheels 72 inches in diameter, and weighed in working order 219,700 pounds. This general design was extensively duplicated, although modifications and improvements were introduced in the locomotives subsequently ordered.

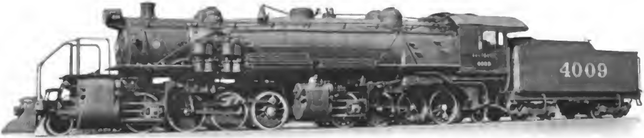
The first locomotives built by The Baldwin Locomotive Works for the Southern Railway to be equipped with fire-tube superheaters, were of the Mikado type, and were completed in 1911. A large number of this

type have since been built, and have proved highly successful in heavy freight service. These locomotives have cylinders 27 by 30 inches, and driving-wheels 63 inches in diameter. They weigh, in working order, 272,940 pounds, and develop a tractive force of 51,700 pounds.

The use of superheated steam in passenger service was begun in 1912, when a group of new Pacific type locomotives were equipped with superheaters.

To meet the increasingly difficult demands of both passenger and freight service, two new types of locomotives—the Mountain (4-8-2) for the former kind of work, and the Santa Fe (2-10-2) for the latter—were designed in 1916, and placed in service early in the following year. The passenger locomotives have cylinders measuring 27 by 28 inches, and driving-wheels 69 inches in diameter, and weigh, in working order, 314,800 pounds. The freight locomotives have 28 by 32-inch cylinders and driving-wheels 57 inches in diameter, and weigh 370,600 pounds. They are fired with mechanical stokers, and develop a tractive force of 71,100 pounds. These locomotives, at the time of their construction, were the heaviest on the System. Their weight slightly exceeds that of the Mallet locomotives of the 2-6-8-0 type, two of which were built for heavy freight service in 1910, but were never duplicated.

The twelve new Mallets represented by locomotive number Fifty-thousand, are designated by the railway company as class $L\overset{S1}{—}56\frac{25\ \&\ 39}{30}84.3$. These locomotives were specially designed for service on the Appalachia Division, which extends from Appalachia to Bristol, Va., a distance of 69 miles. This division presents an undulating profile, with frequent grades of one to two per cent. The most difficult section of the line is between Philips and Mountain. From mile-post 57 to mile-post 65, southbound, the average grade is 1.7 per



LOCOMOTIVE NUMBER FIFTY-THOUSAND. SIDE VIEW

GENERAL DIMENSIONS

Baldwin Construction Number 50,000. Baldwin Class $20\frac{44}{72}\frac{1}{4}$-EE, 6. Railway Company's Class $L^{S1}56\frac{25\ \&\ 39}{30}84.3$

Cylinders

Diameter, H. P.	25"
Diameter, L. P.	39"
Stroke	30"
Valves—H. P., type..Piston, 14" diam.	
Maximum travel	6"
Steam lap	1⅛"
Exhaust clearance	⅜"
Lead	¼"
Valves—L. P., type..Piston, 14" diam.	
Maximum travel	6¼"
Steam lap	⅞"
Exhaust clearance	¼"
Lead	¼"

Boiler

Type	Conical
Diameter at front end	80"
Thickness of barrel sheets	13/16", 7/8", 29/32"
Working pressure	210 lbs.
Fuel	Soft coal
Firebox—Staying	Radial
Length	132¼"
Width	90¼"
Depth, front	85½"
Depth, back	69"

Thickness of firebox sheets—	
Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	⅝"
Water space—Front	6"
Sides	5"
Back	5"
Tubes—Diameter	5½" and 2¼"
Material	5½", steel; 2¼", iron
Thickness	5½", No. 9 W. G.
	2¼", No. 11 W. G.
Number	5½", 42; 2¼", 228
Length	24' 0"
Heating Surface—Firebox	226 sq. ft.
Combustion chamber	109 sq. ft.
Tubes	4658 sq. ft.
Total	4993 sq. ft.
Superheating surface	1260 sq. ft.
Grate area	83 sq. ft.

Driving-Wheels

Diameter, outside	56"
Diameter, center	50"
Journals, main	10" x 22"
Journals, others	9½" x 12"

Truck Wheels

Diameter, front	33"
Journals	6" x 12"
Diameter, back	33"
Journals	6" x 12"

Wheel-Base, Etc.

Driving	41' 1"
Rigid	15' 6"
Total engine	56' 3"
Total engine and tender	86' 10¾"
Length over all	96' 0"
Width over all	11' 1½"
Height over all	15' 6"
Height, rail to center of boiler	10' 0"

Weight

On driving-wheels	374,000 lbs.
On truck, front	27,300 lbs.
On truck, back	25,700 lbs.
Total engine	427,000 lbs.
Total engine and tender	603,000 lbs.

Tender

Wheels, number	8
Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gallons
Fuel capacity	12 tons

cent, with a maximum, for short distances, of 3.4 per cent. This portion of the line is an almost constant succession of curves, many of them of over 10 degrees. Northbound there is a heavy pull out of Bristol yard for a distance of three miles. The grade here averages over 2 per cent with a maximum of 2.9, combined with frequent curves. Near the northern end of the division, between Parkers and Oreton, there are approximately six miles of ascending grade, averaging about 1.5 per cent with a maximum of 1.7. The entire division has but few stretches of level track, and they are exceedingly short.

A line of this kind presents a difficult operating problem, especially where, as in this case, track and bridge conditions necessitate the use of locomotives having limited wheel loads. The traffic on the Appalachia Division consists chiefly of coal, which can be economically moved in heavy trains at moderate speeds. Mallet locomotives are well fitted for service of this kind, as the required tractive force can be developed without using excessive wheel-loads; and while the weight is distributed over a long total wheel-base, the rigid wheel-base is short, so that curves can be easily traversed. This is accomplished by dividing the driving-wheels into two groups, each group having separate frames, cylinders and machinery; and connecting the frames by a hinged joint. The boiler is held in rigid alinement with the rear frames and is supported on the front frames by sliding bearings. Economy in fuel and water consumption is obtained by arranging the cylinders on the compound system, and by the use, on the majority of Mallet locomotives, of highly superheated steam. The cylinders of the rear group of wheels act as the high pressure, and exhaust into the front cylinders, which are of larger diameter and thus act as the low pressure. Flexible pipes are necessarily used to convey the steam from the high pressure to the low pressure cylinders, and from the latter to the exhaust nozzle in the smoke-box.

Locomotive number Fifty-thousand has the 2-8-8-2 wheel arrangement, with four pairs of driving wheels in each group and a two-wheeled truck front and back. The trucks guide the locomotive into curves when running in either direction, and thus protect the driving-wheels against flange wear. With a total locomotive wheel-base of 56′ 3″, the rigid wheel-base is only 15′ 6″, or no greater than that of a Consolidation or Mikado type locomotive having the same sized driving-wheels. Working compound, the locomotive develops a maximum tractive force of 84,800 pounds; and as the weight on the driving-wheels is 374,000 pounds, the ratio of adhesion is 4.40. At starting speeds, the tractive force can be increased to a limited extent, if desired, by using live steam in all four cylinders, as will be subsequently explained.

The boiler barrel is composed of four rings, the second of which is conical, increasing the shell diameter from 80 inches at the first ring to 94¼ inches at the firebox throat. The longitudinal seams are butt jointed and sextuple riveted, and are welded at the ends. The main and auxiliary domes are located on the third ring and the shell is re-enforced by a large internal liner which extends under both domes. The auxiliary dome is placed over an opening 16 inches in diameter, so that the boiler can be entered, when necessary, without dismantling the throttle rigging in the main dome.

The firebox has a combustion chamber 59 inches long, extending forward into the boiler barrel. The seams uniting the firebox and combustion chamber, and the seam between the combustion chamber and tube sheet, are electrically welded; and the boiler tubes are welded into the back tube-sheet. A brick-wall, which serves to baffle and mix the gases, is built across the throat of the combustion chamber. The furnace equipment includes a Franklin power-operated fire-door of the vertical pattern, and a Street type "C" me-

chanical stoker. The grate rocks in four sections, and consists of table bars of the herring-bone pattern, which are supported on cast steel side and center frames. A four-hopper ash-pan, of large capacity, is applied. Two of the hoppers are placed between the wheels, and the remaining two are placed right and left, under the rear end of the firebox and outside the wheels. The pan is fitted with wash-out and blower pipes, so that it can be easily emptied and cleaned. An air opening, five inches deep, is provided all around the firebox under the mud ring.

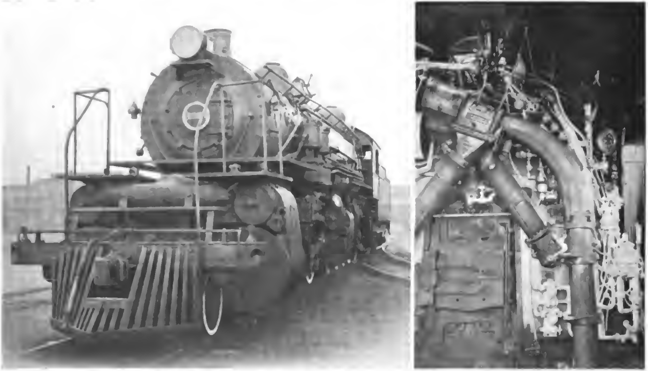
The steam dome is formed of a single piece of flanged steel and measures 33 inches in diameter. It contains a Chambers throttle, which has an external connection with the throttle lever. The superheater is of the fire-tube type, designated as type "A" by the Locomotive Superheater Co. It is composed of 42 units, and provides a superheating surface of 1260 square feet. The smokebox is of the self-cleaning type, and is equipped with a shut-off damper to protect the superheater pipes from overheating when the throttle is closed.

The steam distribution to all the cylinders is controlled by 14-inch piston valves. The high pressure and low pressure valves are alike, except for slight differences in the design of the valve followers and bull-rings. The packing rings are of gun-iron, and are turned with shoulders on their vertical edges to keep them from working out of the valve in case of breakage. The valve gear is of the Southern type, which is standard on this Railway System. This motion is a modification of the Hackworth type of radial gear. The movement of the valve is obtained entirely from a return crank on the main crank pin. The eccentric rod is driven from this return crank, and is suspended, near its forward end, from a block which slides in a curved guide. The direction of running and point of cut-off are determined by the position of the block

in the guide. The movement of the front end of the eccentric rod is transmitted to the valve stem through a link and bell-crank. Simplicity of construction, and a comparatively small number of parts subject to wear, are among the special advantages claimed for this gear.

The high and low pressure valve motions on this locomotive are controlled by a power reverse gear of the Ragonnet type, having an auxiliary steam connection. The reverse shaft of the rear, or high pressure engine, is supported by the valve motion bearers, while that of the front or low-pressure engine, is supported on the lower casting of the forward waist-bearer. A jointed reach rod, placed on the center line of the locomotive, connects the two reverse shafts. At its forward end, this rod is pinned to a transverse beam, the ends of which are connected with the vertical arms of the reverse shaft by means of short links. This arrangement was made necessary because, owing to the construction of the waist bearer, it was impossible to place a vertical arm on the center of the reverse shaft and thus connect directly with the reach rod.

The Simplex system of compounding is applied to this locomotive. This system employs an intercepting valve and a reducing valve which, in the present case, are placed in the high-pressure cylinder saddle. In order to operate the locomotive single expansion, as in starting, or when there is danger of stalling, live steam is admitted against the intercepting valve piston through a manually controlled valve in the cab. The intercepting and reducing valves then take such a position that the high-pressure exhaust is discharged up the stack, while live steam is admitted at reduced pressure direct to the receiver pipe. The high-pressure exhaust steam is conveyed to the smoke-box through a separate exhaust pipe, which is tapped into the exhaust nozzle. On closing the valve in the cab and thus releasing the live steam pressure acting on the intercepting valve



FRONT VIEW AND BACK HEAD OF LOCOMOTIVE NUMBER FIFTY-THOUSAND

piston, the intercepting and reducing valves automatically change their positions, causing the locomotive to work compound.

The pistons have steel heads, of dished section, with bearing-rings riveted on. Each piston has three gun-iron packing rings. The low pressure pistons have extended rods. The guides and cross-heads are of the two-bar type, and in accordance with the Railway Company's practice, the piston rods are bolted to the cross-heads instead of keyed. The front and back cross-heads are interchangeable.

The main frames are vanadium steel castings, five inches wide and seven inches deep over the driving pedestals. The articulated connection between the front and rear frames is designed in accordance with patents granted to the builders, and is a detail of interest. The tongue, or radius bar, forming this connection, is attached to the front frames by means of a transverse, horizontal pin. This pin is supported in a steel casting, which forms a strong transverse brace at the rear end of the front frames, and serves as a fulcrum for the driving brake shaft. The rear end of the radius bar is attached to a vertical pin, which is mounted in a suitable pocket formed in the high-pressure cylinder saddle. This pin passes through a case-hardened, spherical bushing, which is inserted into the radius bar. With this construction the front and rear frames can have relative movement in a vertical plane, when passing over uneven tracks or sudden changes in grade, without causing binding at the articulated joint.

The boiler is supported on the front frames by two waist bearers, composed of steel castings. The controlling springs are mounted on the front bearer. The lower casting of each bearer is fitted with a brass faced shoe, on which the upper casting slides. The bearing surface is lubricated, and the brass face can be replaced when worn. Liners are riveted to the boiler above the waist bearers and high pressure cylinder sad-

dle, and are placed outside the shell to facilitate caulking.

The leading truck is center bearing, and is of the Economy constant resistance type. It is equalized with the first and second pairs of driving-wheels as in a Consolidation locomotive. The trailing truck is side bearing, and the rear group of wheels is continuously equalized on each side of the locomotive. The main driving boxes, of both the front and rear group of wheels, are of the Cole extended pattern.

This locomotive is equipped with four sand-boxes, which are piped to deliver sand under the front and rear driving-wheels of each group. The bell is placed on the round of the boiler, to keep within the specified height limit. Further equipment details include cylinder by-pass valves of the Mellin pattern, steam chest relief valves, and flange lubricators on the front driving-wheels of each group.

The tender is carried on equalized pedestal trucks, and has a built-up frame composed of 12-inch longitudinal channels with white oak bumpers. The engine and tender truck wheels are of forged and rolled steel, and were manufactured by the Standard Steel Works Co.

PLANTS

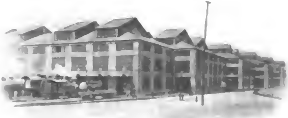
Reference has been made to the fact that the principal plant of The Baldwin Locomotive Works has always been located in the city of Philadelphia. One of the illustrations on page 22 shows the modest shop in which Mr. Baldwin's first locomotives were constructed. This shop was located in Lodge Alley, a small street in the vicinity of Eighth and Market Streets. The facilities here early became inadequate, and in 1835 the business was removed to a new shop, located at Broad and Hamilton Streets. In this vicinity there was, for many years, ample room for plant extension, which was effected as rapidly as required by the growth of the industry.

In 1873 the shops of the former Norris Locomotive Works, at 17th and Hamilton Streets, in the immediate vicinity of the Baldwin plant, were purchased, thus providing increased facilities which were urgently needed. The total area covered by the enlarged plant was nine acres, of which between six and seven acres were under roof. The annual capacity of the Works was 500 locomotives, and the maximum force employed 3000 men. The heaviest locomotives built at that time were of the Consolidation (2-8-0) type, weighing approximately 50 tons each.

In 1904, the year of the Louisiana Purchase Exposition, held at St. Louis, the annual capacity was 2000 locomotives, and the number of employees 15,800. It became apparent, about this time, that it would be impossible to extend the Philadelphia plant sufficiently to meet the needs of the future. Accordingly, in 1906, a tract of 184 acres was purchased at Eddystone, near Chester, Pa., where foundries and blacksmith shops were erected. This was the beginning of a plant which, as increased facilities were demanded, was steadily enlarged; until the tract now covers a total of 506.29 acres, of which 76 acres are under roof.

THE OLD SHOP IN LODGE ALLEY

THE PRESENT PHILADELPHIA PLANT



ERECTING SHOP No. 1, EDDYSTONE PLANT

ERECTING SHOP No. 2, EDDYSTONE PLANT

The Eddystone plant now includes a large iron foundry, with pattern shops and pattern storage houses; also blacksmith shop, spring shop, boiler shop, grate shop, wheel shop, driving-box shop, and two large erecting shops, one of which has recently been completed. A number of these shops were formerly used for the manufacture of shells, but are now being devoted exclusively to locomotive work. The plant contains approximately 26 miles of standard gauge railroad track, in addition to a considerable amount of narrow gauge industrial track. A complete equipment of motive power and rolling stock is operating on these tracks.

The total consumption of electrical power at the Eddystone plant is 13,000 kilowatts, the greater part of which is purchased from outside and transformed to a lower voltage at thirteen transformer stations. All the heating and power plants are designed with a special view to economy in fuel consumption, and are equipped with mechanical stokers. Special attention is being given to the comfort and well-being of the employees. A large restaurant, on the cafeteria plan, has been built; there is a dispensary in each section of the plant, and the sanitary equipment is of the latest type.

In addition to the locomotive shops, there are located, on the Eddystone tract, two complete plants which were erected in 1915 and are owned by The Baldwin Locomotive Works. One of these plants is under lease to the Midvale Steel & Ordnance Co. (Eddystone Rifle Plant) for the manufacture of rifles, while the other is under lease to the Eddystone Munitions Co. for the manufacture of ammunition. This latter company is wholly owned by The Baldwin Locomotive Works. The buildings comprising these plants are so designed that they can, at the expiration of the leases, be utilized as locomotive shops.

The frontispiece gives a bird's-eye view of the entire Eddystone plant. The large building in the foreground is the shop occupied by the Eddystone Munitions Co. The view shows the appearance of the river front when enlarged docking facilities, which are now under consideration, have been completed. The crane shown on one of the piers is of 50 tons capacity, and is used for loading sea-going vessels.

The Eddystone plant has direct track connection with the Pennsylvania R. R., the Baltimore and Ohio R. R. and the Philadelphia and Reading Ry.; so that exceptionally complete shipping facilities, both by rail and vessel, are provided.

The steady expansion at Eddystone, and the transfer of a considerable amount of shop equipment from Philadelphia to that point, have necessitated more or less rearrangement of the Philadelphia plant. Facilities here have been increased during recent years by the construction of an eight-story reinforced concrete building, measuring 98' 6" by 396', which is occupied by machine shops; also by an addition, measuring 90 by 97 feet, to the truck shop. The former Philadelphia erecting shop is now used as a boiler shop; while the 26th Street shop, which was formerly used for finishing and testing locomotives, is now a tender shop.

While the locomotive as a unit has enormously increased in weight and complexity, the rated capacity of the combined Philadelphia and Eddystone plants is now 3000 locomotives per annum; and the employees number 21,500. The consumption of various materials is as follows:

Iron and steel—20,900 tons per month.
Fuel oil—206,000 gallons per week.
Coal—400 tons per day.

The accompanying diagram represents graphically the total production of The Baldwin Locomotive

Works from the date of its founding to the completion of locomotive number Fifty-thousand in September, 1918. In this connection it is interesting to note that:

Locomotive No. 1 was built in 1832.
Locomotive No. 1000 was built in 1861.
Locomotive No. 10,000 was built in 1889.
Locomotive No. 25,000 was built in 1905.
Locomotive No. 50,000 was built in 1918.

Numerically, therefcre, the production of the past thirteen years has equalled that of the previous seventy-three. This is an impressive illustration of the tremendous growth of the locomotive building industry—and therefore of the railroad industry in general—since the beginning of the present century.

THE CHICAGO PLANT

In 1911, the Board of Directors of The Baldwin Locomotive Works authorized the purchase of a tract of 370 acres at East Chicago, Indiana. This proposed plant is not as yet in operation. All is in readiness to erect it as soon as industrial and labor conditions warrant such expansion.

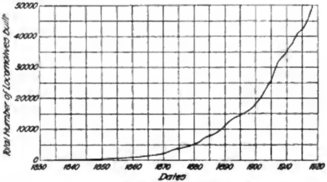
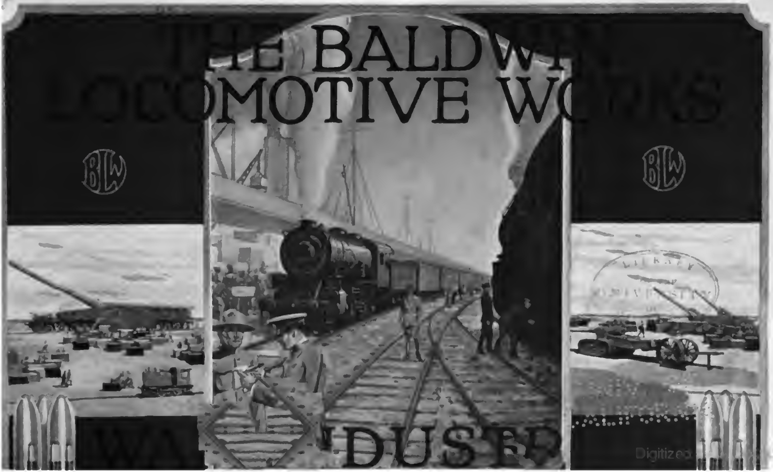


DIAGRAM ILLUSTRATING LOCOMOTIVE PRODUCTION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THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U.S.A.

War Industries

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WILLIAM L. AUSTIN	Vice Chairman
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Record No. 93

1919

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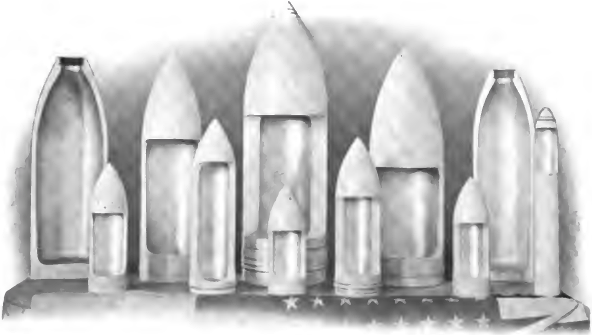


1 2 3 4 5 6 7 8 9 10 11

Types of Shells Manufactured for the Allied Governments

1 and 8. 270 m m high explosive—French
2. 5-inch shrapnel—British
3 and 10. 220 m m high explosive—French
4 and 7. 6 inch—British
5. 12-inch—British
6. 5-inch high explosive—British
9. 4 7-inch high explosive—British
11. 3-inch shrapnel—Russian

War Activities of The Baldwin Locomotive Works

AFTER winning one of the greatest battles of the war, General Joffre is reported to have said:—"This is a railway war. The battle of the Marne was won by the railways of France." And while this statement may, at first sight, appear to be extreme, it is literally true; for success or defeat, in a present day battle, depends chiefly upon the rapidity with which large masses of men can be moved and the guns served with ammunition; and this must be accomplished by the railways, aided by motor trucks. The amount of ammunition expended during a period of intensive fighting has been almost beyond comprehension. In the attack and defense of Verdun, for example, approximately 60,000,000 shells, representing 3,000,000 tons of steel, were expended in thirty weeks; and the railways moved the greater part of this material to the firing line.

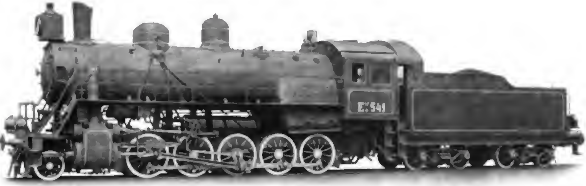
When the conflict broke out in August, 1914, its significance was at once realized by The Baldwin Locomotive Works; and steps were immediately taken to place the manufacturing facilities of the Company at the disposal of the Allied Governments. This could readily be done, because domestic business was at a comparatively low ebb, and the Baldwin plants were working at but a fraction of their capacity.

The pressing needs for ordnance, ammunition and other supplies by France and Great Britain, in order to meet the superior preparations of Germany, were such that all efforts in these early days of the war were directed towards the development of armament and munitions. In Russia, however, greater distances and a desperate shortage of motive power and equipment necessitated the purchase of locomotives. Mr. S. M.

Mallet Articulated Compound Locomotive for the Vologda-Archangel Ry., Russia
Gauge, 3'-6"; Cylinders, 13" and 18" x 22"; Driving-wheels, diam., 44"; Weight, total Engine, 105,800 pounds

Vauclain, who was then Senior Vice President of The Baldwin Locomotive Works, visited Russia in the fall of 1914 and also early in 1915, and was instrumental in securing a large part of this business.

The first order for locomotives resulting from his visit was placed in November, 1914, and called for thirty Mallet locomotives of the 0-6-6-0 type as illustrated above. These were of a gauge of three feet, six inches, and were successfully and rapidly completed and shipped. They were used on the Vologda-Archangel Ry., connecting the broad-gauge railways of Russia with the port of Archangel on the White Sea; the only water outlet in the West after the closing of the Black Sea. This order was followed by others, placed later by the Russian Government, and covering large numbers of heavy Decapod locomotives of a gauge of five feet, gasoline locomotives of a gauge of seventy-five centimetres (2' 5½"), gasoline trucks and gasoline tractors. The Decapod locomotives are illustrated on page 5 and the gasoline locomotives on page 6. As it was impossible, owing to the Bolshevik revolution, to deliver all of the Decapod locomotives to Russia, one hundred of them were purchased by the



Decapod Type Locomotive for the Russian State Rys.
Gauge, 5'-0"; Cylinders, 25" x 28"; Driving-wheels, diam., 52"; Weight, total Engine 200,000 pounds

United States Government and were modified so that they could be used temporarily on the railways of the United States.

The gasoline locomotives, when properly handled, emit practically no smoke. For this reason they are well fitted for trench service, as they are less conspicuous, especially during the day-time, than steam locomotives.

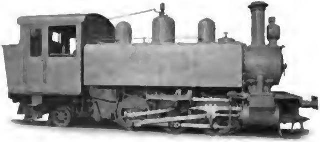
The French Government, late in the summer of 1914, sent a mission to the United States to make certain purchases. Early in November, 1914, the mission received cable instructions from France to purchase twenty tank locomotives of a gauge of sixty centimetres (1' 11⅝"), which were to be built to American designs and shipped as promptly as possible. The Baldwin Locomotive Works took this order on November 3rd, and the twenty locomotives, boxed and ready for shipment overseas, left the Works on November 21st. One of these locomotives is illustrated on page 6. Following this came a number of important orders from the French Government for locomotives to be used in military

Gasoline Locomotive for the Russian Government
Gauge, 2'-5½"; Weight, 15,000 pounds

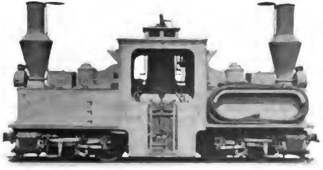
service. With the advent of trench warfare, during the winter of 1914-1915, it became necessary to develop a vast system of narrow-gauge railways on the West Front in order to handle troops and supplies. The French built these lines to a gauge of sixty centimetres (1' 11⅝") and this gauge was subsequently adopted by the British and American armies. The track was so built that it could be quickly laid or shifted to suit requirements. For operation over these railways in the advanced areas, the French Government purchased, from The Baldwin Locomotive Works, 280 locomotives of a special type, known as the Pechot, which were of French design and were built to the metric system. These locomotives, as illustrated on page 7, are carried on two steam driven trucks or bogies, giving them unusual flexibility and excellent track riding qualities. Notwithstanding the complexity of the design, every requirement of the French Government as to delivery was promptly met.

Six-Coupled Tank Locomotive for the French Government
Gauge, 1'-11⅝"; Cylinders, 9" x 12"; Driving-wheels, diam., 26"; Weight, total, 29,000 pounds

In addition to the locomotives just referred to, the French Government ordered a large number of gasoline locomotives from The Baldwin Locomotive Works, and also a number of fireless steam-storage locomotives, both of which are shown on page 8. In the latter type the boiler is replaced by a cylindrical reservoir, which is charged with hot water and steam at high pressure from a stationary plant. The pressure of the steam is reduced before it is used in the cylinders; and as the steam is drawn off, the water in the reservoir gradually evaporates, until the storage pressure is lowered to a point where recharging becomes necessary. Locomotives of this type are specially fitted for work about explosive plants, or in other localities where fire risks must be absolutely eliminated.

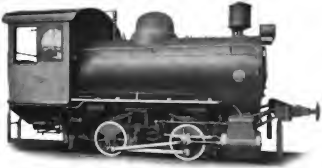


Six-Coupled Tank Locomotive for the French Government
Gauge, 3'-3⅜"; Cylinders, 13" x 16"; Driving-wheels, diam., 34"; Weight, total, 55,500 pounds



Pechot Type Locomotive for the French Government
Gauge, 1'-11⅝"; Cylinders, 6.89" x 9.45"; Driving-wheels, diam., 25.59"
Weight, total, 28,200 pounds

In addition to the locomotives for the French Government, The Baldwin Locomotive Works built a large number of heavy freight locomotives of the Mikado (2-8-2) type for the Paris, Lyons & Mediterranean Railway and the Nord Railway. These locomotives have balanced compound cylinders; they were designed in accordance with French practice, and were built throughout to the

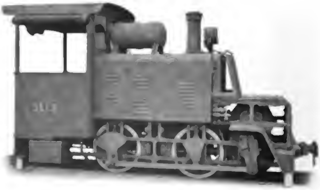


Four-Coupled Fireless Locomotive for the French Government
Gauge, 4'-8½"; Cylinders, 15" x 16"; Driving-wheels, diam., 30"; Weight, total, 42,750 pounds

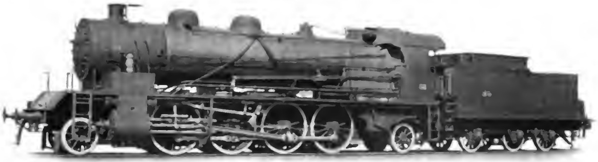
metric system of measurement. One of them is illustrated on page 9.

At the outbreak of the war the British Government, in addition to using French equipment, ferried across the Channel several hundred locomotives taken from service on the British railways. As the operations of the British armies in France increased, however, Great Britain became a heavy purchaser of locomotives in the United States, the great majority of the orders being placed with The Baldwin Locomotive Works. The total number of locomotives thus ordered during the years 1915-1917 was 960. Of these, 495 were of a gauge of sixty centimetres (1' 11⅝"), all of them being of the 4-6-0 type as shown on page 16; while the remainder were of standard gauge, and represented several types.

Every effort was made during this period, to meet the war demands of the Allied Nations, and their orders were given preference. Many serious difficulties had to be overcome in order to complete these orders promptly,



Gasoline Locomotive for the French Government
Gauge, 1'-11⅝"; Weight, 15,000 pounds

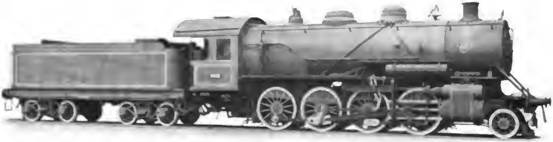


Mikado Type Locomotive for the Paris, Lyons and Mediterranean Ry.
Gauge, 4'-9"; Cylinders, 20.08" x 25.59" and 28.35" x 27.56"; Driving-wheels, diam., 65.36"; Weight, total Engine, 194,900 pounds

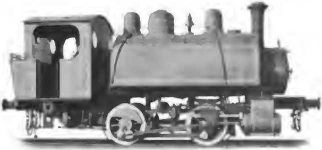
but the requirements were successfully met. One of the Baldwin officials had the satisfaction, while in London, of being told by Sir Guy Granet, then in control of railways for the War Department of Great Britain, that if it had not been for the prompt and efficient deliveries of Baldwin locomotives, some of the accomplishments of the British Army would not have been possible.

During this period the Baldwin products, which were being supplied to the Allied Governments, were not confined to locomotives, as orders were taken for the machining of a large number of shells, varying in calibre from four and seven-tenths inches to twelve inches. These shells were furnished to the British and French Governments. They were manufactured in such of the locomotive shops as were available for the purpose, and also in new shops, specially built and equipped for this kind of work.

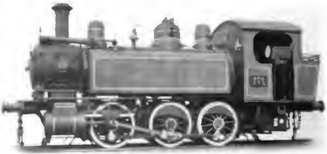
In connection with the manufacture of shells, mention should be made of the construction, in 1915, of two large plants on the Eddystone property of The Baldwin Locomotive Works. One of these plants was leased to the Remington Arms Company of Delaware, afterwards acquired by the Midvale Steel and Ordnance Company



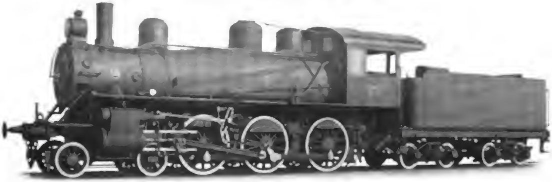
Consolidation Type Locomotive for the British Government
Gauge, 4'-8½"; Cylinders, 21" x 28"; Driving-wheels, diam., 56"; Weight, total Engine, 162,510 pounds



Four-Coupled Tank Locomotive for the British Government
Gauge, 4'-8½"; Cylinders, 14" x 22"; Driving-wheels, diam., 42"; Weight, total, 78,100 pounds



Six-Coupled Tank Locomotive for the British Government
Gauge, 4'-8½"; Cylinders, 16" x 24"; Driving-wheels, diam., 48"; Weight, total, 102,800 pounds



Ten-Wheeled Locomotive for the British Government
Gauge, 4'-8½" Cylinders, 19" x 26"; Driving-wheels, diam., 62"; Weight, total Engine, 141,200 pounds

Six-Coupled Double-Ender Tank Locomotive for the British Government
Gauge, 4'-8½"; Cylinders, 17" x 24"; Driving-wheels, diam., 44"; Weight, total, 150,900 pounds

(Eddystone Rifle Plant), and was first used for the production of Enfield rifles, model of 1914, for the British Government. Subsequently, the plant manufactured rifles for the United States Government, .300-calibre, U. S. model 1917. The capacity finally reached more than 6000 rifles per day, and the plant supplied nearly two-thirds of all the rifles used in combat by the American Army in France. This was a notable achievement; and the capacity of the Eddystone Plant, at the termination of hostilities, exceeded that of any other rifle plant then in operation.

Eddystone Rifle Plant, Midvale Steel and Ordnance Co.

Plant of Eddystone Munitions Co.

United States Military Rifle, .300-Calibre, U. S. Model 1917
Manufactured by Midvale Steel and Ordnance Co., Eddystone Rifle Plant

The second plant referred to was erected as a result of the receipt of large orders for complete ammunition from the British Government. This ammunition was manufactured by the Eddystone Ammunition Corporation, a Company organized for the purpose by Mr. S. M. Vauclain, and owing its existence to his energy and directive ability. The operations of this Company were satisfactorily terminated in 1917. The United States Government requested, at this time, that the equipment and machinery of the Company be kept fully employed in its service. A new corporation was accordingly organized under the title of Eddystone Munitions Company, and to it was leased the property formerly occupied by the Eddystone Ammunition Corporation. The new Company manufactured large quantities of ammunition for the United States Government and continued in operation until after the signing of the armistice. Its entire capital stock was owned by The Baldwin Locomotive Works.

The plants leased to the Midvale Steel and Ordnance Company and the Eddystone Munitions Company were so designed that the buildings could, at the expiration of the leases, be utilized as locomotive shops. The construction of these plants, and the results achieved through their operation, constitute one of the great industrial achievements of the war.

After the United States entered the war in April, 1917, all industries manufacturing war supplies received a great stimulus. A large organization of railroad men,

Rifle Float in Draft Parade
Philadelphia, September 1, 1917

Twelve-Inch Shells Ready for Shipment

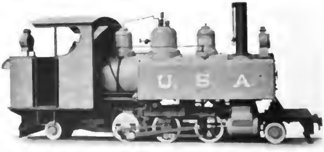
Ten-Wheeled Six-Coupled Tank Locomotive for the British Government

Gauge, 1'-11⅝"; Cylinders, 9" x 12"; Driving-wheels, diam., 23½"; Weight, total, 32,500 pounds

including executive officers, was dispatched to France, and there played an important part in the final success, not only of General Pershing's army, but also of the armies of our Allies.

From the summer of 1917 until the termination of hostilities, the Government entrusted The Baldwin Locomotive Works with what were probably the largest and most urgent locomotive orders ever placed in the history of locomotive building. The first of these orders was received on July 17th, and called for 150 standard gauge locomotives of the Consolidation (2-8-0) type. A remarkable record was made in shipping these locomotives, as the first one, illustrated on page 17, was completed on August 10th and the last on October 1st. Subsequent orders included large numbers of similar locomotives, which became popularly known as "Pershing engines." A number of these were transferred, while under construction, to the French Government.

Through the energy and initiative of Mr. S. M. Felton, Director-General of Military Railways, and his Mechanical Aide, Colonel Milliken, an interesting method



Six-Coupled Double-Ender Tank Locomotive for the United States Government

Gauge, 1'-11⅝"; Cylinders, 9" x 12"; Driving-wheels, diam., 23½"; Weight, total, 33,700 pounds

Consolidation Type Locomotive for the United States Government. The First "Pershing Locomotive" Built
Gauge, 4'-8½"; Cylinders, 21" x 28"; Driving-wheels, diam., 56"; Weight, total Engine, 166,400 pounds

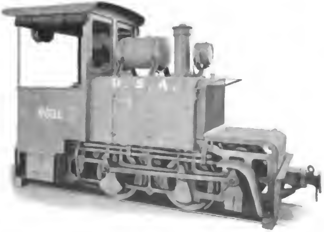
was developed of shipping the Pershing locomotives to France, erected complete with the exception of the smoke stack, cab and a few other details. The locomotives and tenders were placed in the holds of the vessels on their own wheels, and when unloaded at St. Nazaire, France, were prepared for service with but little delay. This was a matter of importance, especially during the last few months of the war; because as the Allied armies advanced and the Germans receded, the transportation requirements of the former naturally increased, and the need for additional locomotives became more and more urgent. Had it become necessary to carry active military operations far into Germany, the need of additional locomotives and railway equipment would have become still more pressing. At the conclusion of hostilities, the building program of The Baldwin Locomotive Works called for the completion of 300 Pershing engines per month; and in consideration of the difficulties in obtaining materials promptly, and in securing an adequate supply of labor, the record made in the construction and delivery of these locomotives was unprecedented.

In addition to the Pershing engines, orders from the

Government included narrow-gauge steam locomotives of the 2-6-2 type, and three sizes of gasoline locomotives, the largest of standard, and the other two of narrow gauge. These locomotives are illustrated on this page, and on pages 16 and 19.

Among the most interesting products of The Baldwin Locomotive Works since the entry of the United States into the war, have been the railway gun mounts for the United States Navy. These mounts were built to carry fourteen-inch rifles, fifty calibres in length, which had been furnished by the Navy. The complete designs of the mount were prepared at the United States Naval Gun Factory, Washington Navy Yard. The mounts were erected, and the guns assembled with them, at the Eddystone plant of The Baldwin Locomotive Works. The first five mounts were ordered on February 18th, 1918; the first one was completed and shipped to Sandy Hook Proving

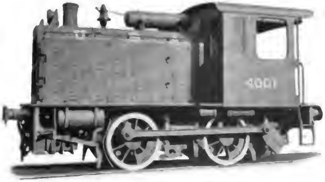
Gasoline Locomotive for the United States Government
Gauge, 1'-11⅝"; Weight, 15,000 pounds



Gasoline Locomotive for the United States Government
Gauge, 1'-11⅝"; Weight, 10,000 pounds

Grounds on April 25th, and the last on May 23rd, 1918. These mounts were shipped to France by the Navy, and were effectively used in action against the German lines of communication for several weeks prior to the signing of the armistice. One of them is illustrated on page 20.

When firing at low angles, the entire weight of the gun is carried by the trucks; but when firing at angles of from fifteen to forty-five degrees, a structural steel foundation, surrounding a pit, is necessary for the purpose of absorbing a portion of the shock and also providing room for the recoil of the gun. The weight of the gun is transferred to the foundation by means of jacks. These foundations were also supplied by The Baldwin Locomotive Works.



Gasoline Locomotive for the United States Government
Gauge, 4'-8½"; Weight, 50,000 pounds

An improved type of mount for fourteen-inch guns was built subsequent to those just described. In this type no separate foundation is necessary, as the gun can be fired at angles up to forty-three degrees without relieving the supporting trucks of its weight.

The Baldwin Locomotive Works has also been engaged in the construction of seven-inch "caterpillar" mounts for the United States Navy. These mounts have broad caterpillar treads, similar to those used on tractors which are designed to operate over rough roads and soft soil. These mounts were designed at the United States Naval Gun Factory, and The Baldwin Locomotive Works contracted to furnish them complete, with the exception of the gun and breech mechanism, which were supplied by the Gun Factory.

This mount, complete with gun, as shown on page 21, weighs about 72,000 pounds, and the bearing pressure under the treads is approximately ten pounds per square inch. The guns are transported in the field by means of Holt tractors of 120 horse-power.

Fourteen-Inch Navy Gun on Railway Mount
Maximum firing elevation, 45 degrees. Maximum effective range, 30 miles

In addition to building complete mounts, The Baldwin Locomotive Works constructed several styles of railway trucks for gun and howitzer mounts. At the time hostilities closed, preparations were being made for the manufacture, on a large scale, of heavy tanks equipped with Liberty motors. These were intended to destroy the wire defenses and machine-gun nests put up by the Germans in their retreat. After the signing of the armistice, however, the order for these tanks was cancelled.

Seven-Inch Gun on Caterpillar Mount

Summarizing, the war activities of The Baldwin Locomotive Works, for all the belligerent nations including our own, comprise the following:

LOCOMOTIVES

Broad-gauge steam locomotives of various types	3246
Narrow-gauge steam locomotives of various types	1146
Broad-gauge gasoline locomotives	20
Narrow-gauge gasoline locomotives	1139
Total	5551

SHELLS

(Including those manufactured by the Eddystone Ammunition Corporation and the Eddystone Munitions Company.)

3-inch shrapnel	2,300,000
75 m/m shells	2,351,555
4.7-inch shells	225,399
5-inch shells	150,281
6-inch shells	1,068,157
12-inch shells	112,553
12-inch forgings	9,000
220 m/m shells	213,615
270 m/m shells	134,795
Total number of shells	6,565,355
Cartridge cases	1,863,900
Miscellaneous ammunition items	1,905,213

GUN MOUNTS

14-inch railway mounts	11
Foundations for 14-inch mounts	20
14-inch railway mounts, improved type	2
7-inch caterpillar mounts	38
Trucks for gun and howitzer mounts	5 sets

The total number of rifles manufactured at the Eddystone rifle plant was approximately 2,200,000.

The aggregate value of the war contracts executed and delivered by The Baldwin Locomotive Works and its associated companies, the Standard Steel Works Company, the Eddystone Ammunition Corporation, and the Eddystone Munitions Company, was approximately $250,000,000.

The Baldwin Locomotive Works

Record No. 94

Tank-Frame Locomotives

THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U.S.A.

Tank-Frame Locomotives

RECORD NO. 94

1919

CODE WORD—REDORNABAR

Eddystone Plant of The Baldwin Locomotive Works Showing Docking and Shipping Facilities

Tank-Frame Locomotives

THE locomotives illustrated and described in the following pages are all of narrow gauge, and represent a type which is particularly suitable for industrial, contractors, and other classes of special service. They are also well fitted for use on light railway tracks of the Decauville type, such as are frequently employed on industrial lines in foreign countries. Work of this character requires a locomotive of simple design and strong construction, suitable for operation on rough tracks and sharp curves, and having easily accessible working parts.

These locomotives have steel plate frames, which are spring supported and of ample strength. The frames constitute the sides of the water tank, which is placed between them. This location of the water tank, under the boiler, results in a comparatively low center of gravity for the entire locomotive. This is an important feature, especially on exceptionally narrow gauge track, as it reduces the liability to overturn.

As the space between the frames is occupied by the tank, the valve gear, in this type of locomotive, is necessarily placed outside the wheels. A simple design of Marshall gear, modified to suit the requirements of locomotive service, is usually applied; although on the larger sizes, Walschaerts gear is sometimes used. The throttle valve, on the smaller locomotives, is placed outside the dome, and in all cases the steam pipes are external to the boiler. With this construction, the machinery and piping are easily accessible.

These locomotives can be designed to burn coal, wood or oil for fuel. The Rushton Improved Smokestack is specially recommended for use with wood. It is a most efficient spark arrester, is simple in construction, and offers a minimum amount of draft obstruction.

These locomotives are fitted with an efficient type of hand-brake. Couplers and other special equipment are applied to suit the requirements of the purchaser.

Loading a Steamer for Foreign Shipment at the Eddystone Plant

Shipment

TANK-FRAME locomotives of the sizes illustrated in this pamphlet, can be boxed complete, ready for foreign shipment. At the most it is necessary to dismantle only a few external parts, which, if left in place, might materially increase the size of the box. The locomotives are thus practically ready for use on arrival at destination, and can be put in service with a minimum amount of delay.

This method of shipping locomotives was extensively used during the period of the war, when hundreds of small locomotives were shipped, each boxed complete in one case. It was also used with a large number of the "Pershing" Consolidation type locomotives, which are standard gauge engines weighing, without tender, about 83 tons in working order. In the case of these locomotives it was necessary to remove the cab, stack, connecting rods, and a few other fittings. These, however, were packed in the tender, which was shipped complete. Much valuable time was thus saved when preparing the locomotives for service after their arrival in France.

In this connection, attention may be called to the unusually complete shipping facilities of The Baldwin Locomotive Works. All locomotives are erected at the Eddystone plant, which is on the shore of the Delaware River, about twelve miles from Philadelphia. This plant has track connection with three important railroad systems—the Pennsylvania, the Baltimore and Ohio, and the Philadelphia and Reading—and is located on tide-water. Complete docking facilities are provided, and as shown in the illustrations, foreign shipments can be transferred direct from railroad cars to the holds of ocean-going vessels. For this purpose a fifty-ton traveling crane was installed in 1917. Additional docks are now being built, and when these are completed the facilities of the Works for handling foreign shipments promptly will be unsurpassed.

Duplicate Parts

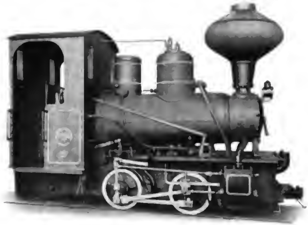
THE locomotives illustrated and described in this pamphlet, like all Baldwin engines, were built to gauges and templets, so that duplicate parts can be furnished at any time, with the guarantee that they will fit.

This is one of the most valuable features of Baldwin service, as it enables a railway having limited shop facilities to maintain its locomotives by securing the needed material, finished and ready for application, direct from these Works. Spare parts are given preference in manufacture, so that prompt shipment is assured.

When ordering spare parts for a Baldwin locomotive, it is only necessary to give the construction number of the locomotive and the names of the parts required. Spare parts for locomotives of other makes will be manufactured from blue-prints furnished by the customer.

The Baldwin Locomotive Works also have complete facilities for repairing and rebuilding locomotives in their own shops. Any new parts required are manufactured and applied, and the locomotives are returned to their owners in first-class condition.

In addition to building locomotives and manufacturing spare parts, The Baldwin Locomotive Works are prepared to furnish general engineering supplies such as boilers, tanks, and any kind of equipment that can be manufactured in a large locomotive building plant. The Works are also prepared to furnish such locomotive specialties as are manufactured by reputable railway supply companies; to build and equip engineering plants, and to aid in general engineering work, both domestic and foreign, in every possible way.



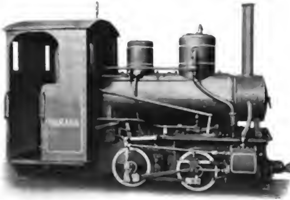
Four-Coupled Tank-Frame Locomotive for Jayme Arthur Marques, Africa

Class 4-6-C, 15

Code Word, REDORNABO

GENERAL DIMENSIONS

Gauge	1' 11⅝"
Cylinders	6" x 10"
Boiler—Diameter	25"
Working pressure	176 lbs.
Fuel	Wood
Firebox—Material	Steel
Length	19¾"
Width	20½"
Depth, front	25¾"
Depth, back	25¼"
Tubes—Material	Iron
Number	32
Diameter	1¾"
Length	5' 4"
Heating Surface—Firebox	13 sq. ft.
Tubes	77 sq. ft.
Total	90 sq. ft.
Grate area	2.8 sq. ft.
Driving Wheels—Diameter	22"
Journals	3¼" x 6"
Wheel Base—Driving	3' 0"
Total engine	3' 0"
Weight—Estimated	
On driving wheels	11,900 lbs.
Total engine	11,900 lbs.
Tank Capacity	114 U. S. gals.
Fuel Capacity	8 cu. ft.
Rails	26 lbs. per yard
Curves—Radius	49 ft.
Service	Plantation



Four-Coupled Tank-Frame Locomotive for The Pleystowe Central Mill Co., Ltd., Australia

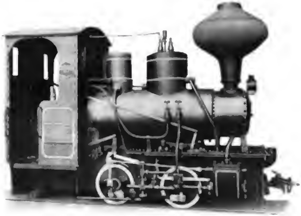
Class 4-6-C, 14 — **Code Word, REDORNARET**

GENERAL DIMENSIONS

Gauge	2' 0"
Cylinders	6" x 10"
Boiler—Diameter	25"
Working pressure	176 lbs.
Fuel	Soft coal
Firebox—Material	Copper
Length	19½"
Width	20⅛"
Depth, front	25¾"
Depth, back	25¼"

Tubes—Material	Brass
Number	32
Diameter	1¾"
Length	5' 4"
Heating Surface—Firebox	15 sq. ft.
Tubes	77 sq. ft.
Total	92 sq. ft.
Grate area	2.7 sq. ft.
Driving Wheels—Diameter	22"
Journals	3¼" x 6"
Wheel Base—Driving	3' 0"
Total engine	3' 0"

Weight—On driving wheels	12,000 lbs.
Total engine	12,000 lbs.
Tank Capacity	102 U. S. gals.
Fuel Capacity	8 cu. ft.
Rails	14 lbs. per yard
Grades	3 per cent.
Curves—Radius	198 ft.
Service	Freight

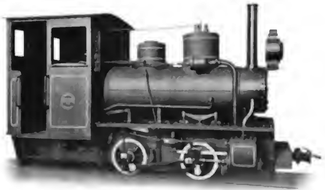


Four-Coupled Tank-Frame Locomotive for H. E. Oving, Jr., Java

Class 4-6-C, 16 — **Code Word, REDORNATOS**

GENERAL DIMENSIONS

GAUGE	1' 11⅝"	TUBES—Material	Iron	WHEEL BASE—Driving	3' 0"
CYLINDERS	6" x 10"	Number	32	Total engine	3' 0"
BOILER—Diameter	25"	Diameter	1¾"	WEIGHT—On driving wheels	12,400 lbs.
Working pressure	176 lbs.	Length	5' 4"	Total engine	12,400 lbs.
Fuel	Wood	HEATING SURFACE—Firebox	13 sq. ft.	TANK CAPACITY	102 U. S. gals.
FIREBOX—Material	Steel	Tubes	77 sq. ft.	FUEL CAPACITY	8 cu. ft.
Length	19¾"	Total	90 sq. ft.	SERVICE	Plantation
Width	20½"	Grate area	2.8 sq. ft.		
Depth, front	25¾"	DRIVING WHEELS—Diameter	22"		
Depth, back	25¼"	Journals	3¼" x 6"		



Four-Coupled Tank-Frame Locomotive for International Engineering & Trading Co., Russia

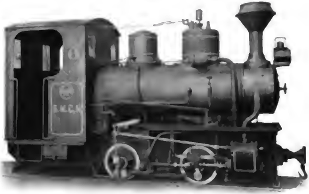
Class 4-8-C, 87 | **Code Word, REDORONS**

GENERAL DIMENSIONS

Gauge	2' 5.53"
Cylinders	7" x 12"
Boiler—Diameter	28"
Working pressure	176 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Length	24 1/8"
Width	23 1/8"
Depth	29"

Tubes—Diameter	1 3/4"
Material	Steel
Number	46
Length	6' 9"
Heating Surface—Firebox	19 sq. ft.
Tubes	140 sq. ft.
Total	159 sq. ft.
Grate area	3.8 sq. ft.

Driving Wheels—Diameter	23"
Journals	3 3/4" x 6"
Wheel Base—Driving	3' 8"
Total engine	3' 8"
Weight—On driving wheels	18,100 lbs.
Total engine	18,100 lbs.
Tank Capacity	185 U. S. gals.
Fuel Capacity	14 cu. ft.
Service	Switching



Four-Coupled Tank-Frame Locomotive for Max Lyon, Chile

Class 4-10-C, 31

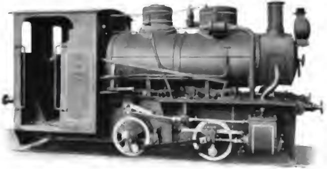
Code Word, REDOTATION

GENERAL DIMENSIONS

GAUGE	1' 11⅝"
CYLINDERS	8" x 12"
BOILER—Diameter	30"
Working pressure	176 lbs.
Fuel	Low grade coal
FIREBOX—Material	Copper
Length	26⅛"
Width	27⅛"
Depth	30½"

TUBES—Material	Steel
Diameter	1¾"
Number	56
Length	7' 0"
HEATING SURFACE—Firebox	21 sq. ft.
Tubes	177 sq. ft.
Total	198 sq. ft.
Grate area	4.9 sq. ft.
DRIVING WHEELS—Diameter	23"
Journals	4" x 6"

WHEEL BASE—Driving	4' 0"
Total engine	4' 0"
WEIGHT—On driving wheels	18,200 lbs.
Total engine	18,200 lbs.
TANK CAPACITY	175 U. S. gals.
FUEL CAPACITY	12 cu. ft.
RAILS	26 lbs. per yard
GRADES	3 per cent.
CURVES—Radius	39 ft.
SERVICE	Mining



Four-Coupled Tank-Frame Locomotive for Bogoslovsk Mining Co., Russia

Class 4-10-C, 32

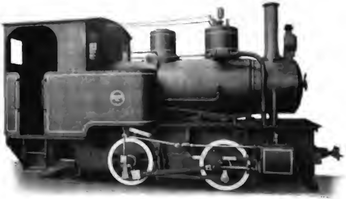
Code Word, REDOUBLAIS

GENERAL DIMENSIONS

Gauge	2′ 10$\frac{3}{16}$″
Cylinders	8″ x 12″
Boiler—Diameter	30″
Working pressure	176 lbs.
Fuel	Brown coal
Firebox—Material	Copper
Length	26″
Width	27$\frac{1}{4}$″
Depth	30$\frac{1}{2}$″

Tubes—Material	Steel
Diameter	1$\frac{3}{4}$″
Number	56
Length	7′ 0″
Heating Surface—Firebox	21 sq. ft.
Tubes	177 sq. ft.
Total	198 sq. ft.
Grate area	4.9 sq. ft.
Driving Wheels—Diameter	23″
Journals	4″ x 6″

Wheel Base—Driving	4′ 0″
Total engine	4′ 0″
Weight—On driving wheels	19,500 lbs.
Total engine	19,500 lbs.
Tank Capacity	200 U. S. gals.
Fuel Capacity	12 cu. ft.
Grades	2 per cent.
Curves—Radius	65.6 ft.
Service	Switching



Four-Coupled Tank-Frame Locomotive for Thunes Mekaniske Vaerksted for Putilow Works, Russia

Class 4-14-C, 276

Code Word, REDOUBLE

GENERAL DIMENSIONS

Gauge	2' 11.83"
Cylinders	10½" x 16"
Boiler—Diameter	36"
Working pressure	176 lbs.
Fuel	Soft coal
Firebox—Material	Copper
Length	27"
Width	31½"
Depth	35½"
Tubes—Material	Iron
Diameter	1¾"
Number	79
Length	7' 10"
Heating Surface—Firebox	28 sq. ft.
Tubes	280 sq. ft.
Total	308 sq. ft.
Grate area	5.9 sq. ft.
Driving Wheels—Diameter	32"
Journals	4½" x 6"
Wheel Base—Driving	5' 3"
Total engine	5' 3"
Weight—On driving wheels	28,500 lbs.
Total engine	28,500 lbs.
Tank Capacity	384 U. S. gals.
Fuel Capacity	20 cu. ft.
Service	Switching

Six-Coupled Tank-Frame Locomotive for the International Engineering & Trading Co., Russia

Class 6-10-D, 7

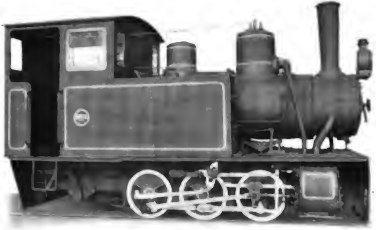
Code Word, REDOUCA

GENERAL DIMENSIONS

GAUGE	2′ 5.53″
CYLINDERS	8″ x 12″
BOILER—Diameter	32″
Working pressure	176 lbs.
Fuel	Wood
FIREBOX—Material	Steel
Length	26 1/8″
Width	27 1/8″
Depth	36 1/4″

TUBES—Material	Iron
Diameter	1 3/8″
Number	66
Length	7′ 8″
HEATING SURFACE—Firebox	26 sq. ft.
Tubes	229 sq. ft.
Total	255 sq. ft.
Grate area	4.9 sq. ft.

DRIVING WHEELS—Diameter	23″
Journals	3 3/4″ x 6″
WHEEL BASE—Driving	4′ 8″
Total engine	4′ 8″
WEIGHT—On driving wheels	22,850 lbs.
Total engine	22,850 lbs.
TANK CAPACITY	200 U. S. gals.
FUEL CAPACITY	32 cu. ft
SERVICE	Switching



Six-Coupled Tank-Frame Locomotive for the British War Mission

Class 6-14-D, 47

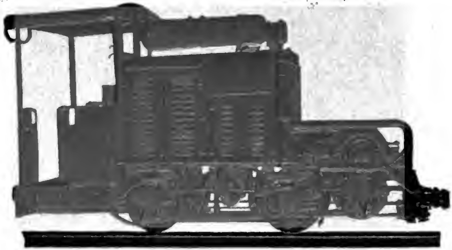
Code Word, REDOUTABLE

GENERAL DIMENSIONS

GAUGE	2' 6"
CYLINDERS	10" x 14"
BOILER—Diameter	34"
Working pressure	165 lbs.
Fuel	Soft coal
FIREBOX—Material	Steel
Length	29 1/8"
Width	27 1/8"
Depth	30 3/4"

TUBES—Material	Iron
Diameter	1 3/4"
Number	70
Length	8' 8"
HEATING SURFACE—Firebox	26 sq. ft.
Tubes	275 sq. ft.
Total	301 sq. ft.
Grate area	5.5 sq. ft.

DRIVING WHEELS—Diameter	28"
Journals	4½" x 6"
WHEEL BASE—Driving	5' 4"
Total engine	5' 4"
WEIGHT—On driving wheels	33,600 lbs.
Total engine	33,600 lbs.
TANK CAPACITY	475 U. S. gals.
FUEL CAPACITY	1 ton
SERVICE	Switching



THE BALDWIN LOCOMOTIVE WORKS

RECORD No. 95

INTERNAL COMBUSTION LOCOMOTIVES

THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA., U. S. A.

INTERNAL COMBUSTION LOCOMOTIVES

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Record No. 95
1919
Code Word—REDOUTAIS

Locomotive of Two-feet Gauge, Used by the Victor Chemical Works

Internal Combustion Locomotives

Ehle Patent

SINCE the introduction of Baldwin gasoline locomotives, several years ago, various changes and improvements have been made, based directly upon experience gained with the earlier locomotives. These machines are meeting the demand for a practical locomotive which, like the automobile, is propelled by an internal combustion motor. Because of the peculiar conditions under which a locomotive must operate, however, something more is required in its design than a mere incorporation of automobile practice.

For several years The Baldwin Locomotive Works experimented with a view to developing an efficient gasoline locomotive which would be simple in construction, and follow steam locomotive design where practicable. Such locomotives, built in accordance with patents granted to A. H. Ehle, have been in successful service since 1910 and are described in the following pages. They have particularly demonstrated their special fitness for work in contracting operations, plantations, quarries, brick yards, lumber mills, smelting plants, light switching in railroad yards, and in other classes of service where loads are to be hauled at moderate speeds and within the range of available motor powers. They are safe, efficient, clean, and dependent upon no source of power external to themselves. Being self-contained, their radius of operation is limited only by the capacity of the fuel tank carried. They are well adapted to those localities where water is scarce, or where the cost of coal or electricity

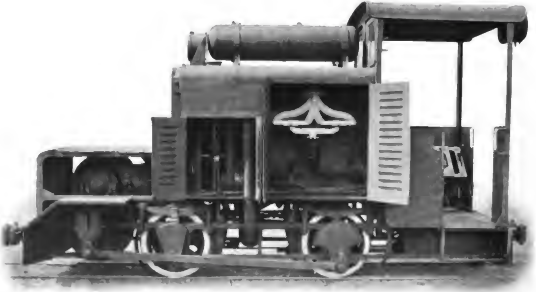
7½-Ton, Two-feet Gauge Locomotive

would make either steam or electric locomotives an expensive, if not a prohibitive investment.

It will also be quite apparent that in isolated places with no power supply, gasoline locomotives offer the advantage of requiring no power house installation or special track equipment. However, it is obvious that the cost of gasoline or other fuel oils, considered in connection with special operating requirements, will in many cases make other forms of motive power more desirable. As with all kinds of haulage problems, an intelligent selection for any given service can be made only after a careful analysis of the particular conditions to be met.

The Baldwin Locomotive Works has had extended experience in the development of all types of locomotives, and is in a position to recommend, without prejudice, the most suitable locomotive for any given service conditions. Baldwin gasoline locomotives are built in a number of standard sizes, the dimensions of which are given in the table on page 33. These locomotives weigh 5, 7½, 10, 15 and 25 tons, and cover a range sufficient to meet the requirements of average industrial service. The 15 and 25-ton locomotives are also fitted for special service where a comparatively heavy locomotive is required, and for switching in railroad yards and terminals. It is recommended that these standard size locomotives be used where practicable. Special designs will, however, be prepared to meet unusual conditions of operation.

Based on previous experience, the designs of Baldwin internal combustion locomotives have recently been revised without, however, modifying the general principles of construction. A number of the locomotives shown in service in the accompanying illustrations, are of the older type. They are included in this instance, because of the excellent service they are rendering. The builders believe that the revised designs represent the most efficient line of internal combustion locomotives in service today.



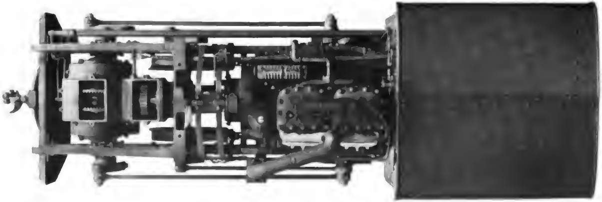
7½-Ton, Two-feet Gauge Locomotive with Hood Opened

General Construction

Baldwin Internal Combustion Locomotives

The plan view herewith shows a locomotive with the radiator and engine cover removed and top of transmission case opened, and illustrates the arrangement of the parts and the application of power from the engine to all four driving wheels.

The engine is vertical, and drives a small bevel pinion, placed at the opposite end of the



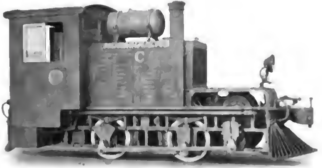
Plan View Showing Arrangement of Parts

Locomotive of 2'-5½" Gauge, Used by the Bach Brick Company, Chicago, Ill. This Locomotive Handles from 200 to 250 Cars per Day. The Capacity of the Plant is over 30,000,000 Bricks per Year.

shaft, either directly or through a system of auxiliary change speed gears. This small bevel pinion is constantly in mesh with two large bevel gears located on the top transverse counter-shaft. With the engine fly-wheel friction clutch engaged and driving either directly, or indirectly through the auxiliary change-speed gears, the large bevels will, of course, run in opposite directions.

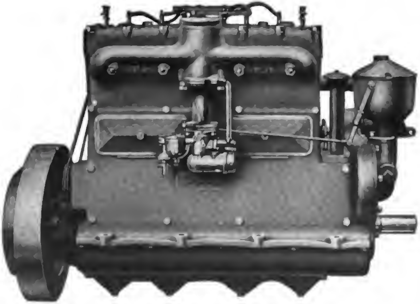
These bevels run loose on the intermediate shaft except when one or the other is engaged by a forward and reverse jaw clutch located midway between the bevel gears. This construction is simple, yet positive, and provides for the operation of the locomotive in either direction.

Two spur gears of different diameters are keyed fast to the top transverse counter-shaft, and these gears are constantly in mesh with corresponding intermediate and high-speed gears located on the jack or driving shaft, directly under the top transverse counter-shaft. These change speed gears, either without or in combination with the auxiliary change speed gears previously mentioned, permit the selection of four speeds in either direction.



5-ton Locomotive for Hormiguero Central Corporation, Cuba

The two jack-shaft gears run loose except when one or the other is engaged by either a high or low speed jaw clutch located centrally on the jack shaft. On the ends of this same jack shaft there are two driving cranks set ninety degrees apart and connected to both pairs of driving wheels by side rods. This method of drive is entirely positive, and corresponds, as far as is practicable, with that found in the most successful steam locomotives. It allows free vertical motion for the driving wheels and complete spring suspension of the entire locomotive.



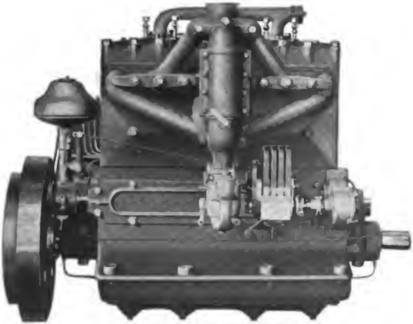
5" x 7½" Four-cylinder Engine, Valve Side

It will be seen that all control levers are within easy reach of the motorman; and the operator can, without leaving the cab, observe the engine and give it minor adjustments while running.

Engines. The engines used in Baldwin gasoline locomotives are water-cooled, built for extremely heavy duty, and are of the four-cycle, four and six-cylinder type; the four-cylinder being used on the 5, 7½ and 10-ton sizes, and the six-cylinder on the 15 and 25-ton sizes. These engines are specially designed to withstand the most severe service conditions.

The familiar jump-spark method of ignition is used, with either storage battery or magneto as the source of current. Lubrication is effected by a mechanical force-feed oiler, combined with splash in the crank case.

One of Sixty-three 5-ton Locomotives of 60-centimetres Gauge Built for the United States Government for Military Service



6¼" x 8". Four-cylinder Engine, Valve Side

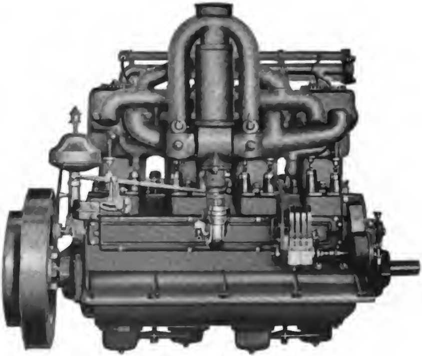
The 5-ton locomotive has four cylinders measuring 5 x 7½ inches, which are cast en bloc, with a removable cylinder head casting. The 7½-ton locomotive also has four cylinders, which measure 6¼ x 9 inches, and are cast in pairs, with removable heads. The 10, 15 and 25-ton sizes have the cylinders cast separately, four being used in the 10-ton size and six in each of the other two. The cylinders of the 10 and 15-ton locomotives are 7¼ x 9 inches, while those of the 25-ton design are 7¾ x 12 inches. All parts are so designed and finished as to be absolutely interchangeable in engines of the same class.

These engines are built for us by the Minneapolis Steel and Machinery Company. This Company's extensive experience in the building of internal combustion engines, coupled with that of The Baldwin

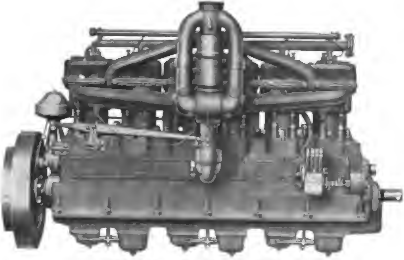
Locomotive Works as locomotive builders, is a guarantee that the engines used in Baldwin internal combustion locomotives will be fully equal to meeting the most severe service requirements.

Fuel. These internal combustion locomotives can be equipped to burn gasoline, naphtha, alcohol, kerosene, or distillates of 42° Baumé or higher, and having a flash point of not over 120° Fahrenheit. We should be advised, in advance of an order, which fuel is to be used, so that the proper modifications can be made in the motor, manifold, carburetor, etc.; since after placing the locomotive in service the change from one fuel to the other cannot be made, with the best results, without corresponding alterations of the parts in question.

To those interested in the detail construction and the specifications of the engines themselves, we shall



7¼" x 9", Four-cylinder Engine, Valve Side



7¼" x 9", Six-cylinder Engine, Valve Side

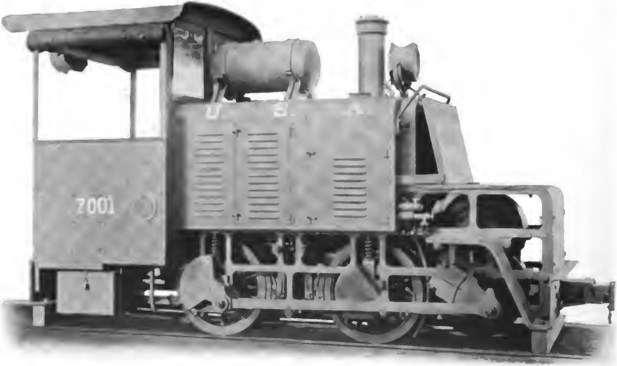
be glad to forward a catalogue issued by the manufacturers.

Self Starter. This device is usually applied, and is practically indispensable on all but the smallest locomotives. Its application increases the first cost of the locomotive, but such convenience and fuel economy result from the use of the device, that it is recommended for all sizes.

The self starter is a convenience, in that it saves labor and makes practicable the use of electric headlights. The fuel economy results from the fact that, as the motor is so easily started, it can be stopped without inconvenience to the operator, whenever the locomotive is standing. Without the self starter the motor would usually be kept running while making short stops, and the consumption of fuel continued at such times.

The device itself consists of an electric motor, which drives the engine fly-wheel through reduction gearing.

Locomotive of Two Feet Six Inches Gauge, Used by the Cayey Sugar Company, Porto Rico. Note full length Canopy for Tropical Service

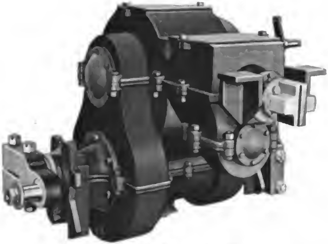


One of One hundred and twenty-six 7½-ton Locomotives of 60-centimetres Gauge Built for the United States Government for Military Service

The motor receives its current supply from a storage battery, and this, in turn, is charged from a generator driven by the main engine. The charging of the battery is entirely automatic, and requires no attention on the part of the operator.

Transmission and Drive. No part of the locomotive is of more importance than the transmission; since upon this depends the successful application to the driving wheels, of the power developed by the motor. In the Baldwin gasoline locomotive, the transmission has been specially designed to withstand the strains, shocks and continued wear and tear incident to mechanical haulage. The gears, shafts, clutches and all other transmission parts are of liberal proportions, and are enclosed in an oil-tight cast-iron housing which constitutes a separate unit. Lubrication is thus easily provided for, and as the various parts are permanently held in rigid alinement it is seldom necessary to give the transmission any attention, except to occasionally replace the oil. The gears have wide faces with accurately machined teeth, and together with the shafts and clutches are made of steel. The bevel pinion and top transverse counter-shaft, together with the shafts of the auxiliary change-speed gears, are mounted on either annular ball-bearings or roller bearings, as required. This is an expensive but important detail of construction, which insures perfect alinement of the gears and maximum efficiency

View of Transmission with Cover Removed

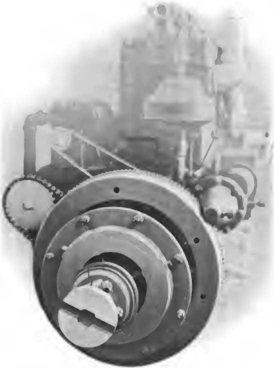


Assembled Transmission Showing Oil Tight Housing

of power transmission. Friction between the large bevel gears and top countershaft, when running loose, is eliminated by mounting the gears on roller bearings. The final connection from the transmission to the driving wheels is through connecting and side rods. Four positive gear ratios are provided for each direction of running. The low gear, giving a speed of approximately two miles per hour, is used for starting and accelerating the load; the second gear, giving a speed of approximately four miles per hour, is used for exceptionally heavy pulling; the third gear, giving approximately six miles per hour speed, is used for light hauling or normal running; and the fourth or high speed gear is used for running light. This last gives a speed of approximately twelve miles per hour. When selecting a locomotive for any definite service conditions, the performance is usually based on the second or third gear speed.

Jack Shaft or Lower Half of Transmission

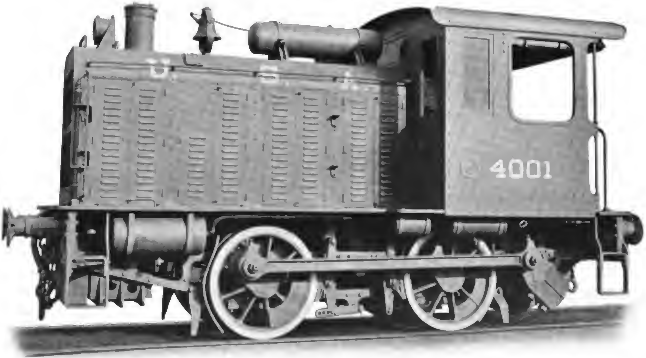
Two-feet Gauge Locomotive Used by Hawley & Fridner, Railroad Contractors



Clutch and Fly-wheel

Friction Clutch. The main friction or driving clutch is of the multiple disc type, and is placed in the engine fly-wheel. It is entirely self-contained, and the discs run in a bath of oil within the clutch housing. The combined surface is extremely large for the horse power transmitted; hence the engagement of the discs is smooth and gradual, and the clutch can be slipped for long periods without excessive heating or perceptible wear. When fully engaged, the clutch will not slip until it is intentionally released.

Frames. The main frames are of the cast-steel bar type, and are generally similar to those used in steam locomotive practice. They are much stronger than cast-iron frames of equal weight, and because of their design the engine and running gear are more accessible. The side and end pieces are accurately fitted and securely bolted together with turned bolts in reamed holes. The frames are usually placed between the wheels, but in locomotives of exceptionally narrow gauge, it is necessary to place them out-



One of Twenty Standard Gauge, 25-ton, Four-coupled Locomotives Built for the United States Government for Military Service

One of Four Special Locomotives Used by the City of Chicago in Tunnel Service

One of Four Special 5-ton Locomotives Used by the City of Chicago

side in order to provide room for the motor and transmission. The illustrations show both inside and outside frame locomotives.

Wheels, Axles, Springs, Etc. The driving wheels have cast-iron centers with steel tires shrunk on. The driving wheel and jack-shaft pins are of hammered steel, hydraulically inserted. The axles are of high-grade forged steel, with large journals. The journal boxes are of special design, with removable cellars which are held in place by turned bolts. They are of cast iron and are lined with bronze. The locomotives are supported on leaf springs of oil-tempered steel.

Side Rods. The side or connecting rods are of hammered steel with solid ends, and have bronze bushings hydraulically inserted.

One of 350 Special Six-coupled Locomotives Built for the Russian Government. Gauge, 2'-5½"; Weight, 15,000 pounds

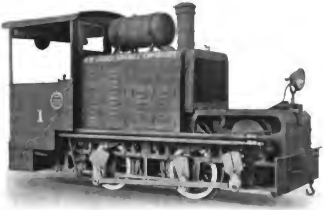
One of Three Standard Gauge Switching Locomotives Built for the Erie R. R. Co. and Operating in Chicago

Brakes. An efficient interlocking hand brake is provided, with shoes on all the wheels. When desired by the customer, a lever or ratchet type of brake can be supplied. The brake-shoes are of the M.C.B. type, and are detachable from the brake-heads.

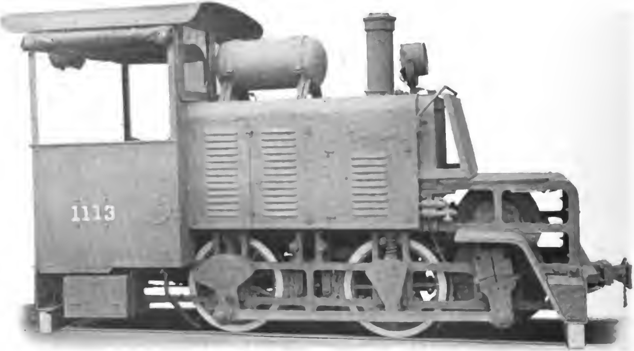
Sanding Device. Four sand-boxes are provided, with separate handles for sanding in front of the leading driving wheels when running in either direction.

Radiator. The radiator is substantially constructed, with unusually large surface and water capacity. It is of such proportions as to prevent over-heating of the engine when developing full power under the most severe hauling conditions, and is set well back from the front end with a view to escaping damage in the event of collision. A constant circulation of air is maintained by a fan driven from the engine.

Fuel Tanks. The fuel tanks are of seamless drawn steel, and are tested to a pressure of 300 pounds per square inch. When possible they are located over the hood as shown in the above illustration, and have a gravity feed to the carburetor. There is thus very little pressure in the feed-pipe, and the liability of any leakage in the connections is reduced to a minimum.



5-ton Locomotive for New Corsica Centrale Corporation, Porto Rico



One of Six hundred 7½-ton Locomotives of 60-centimetres Gauge Built for the French Government for Military Service

7½-ton Locomotive in Industrial Service at the Eddystone Plant of The Baldwin Locomotive Works

Cab or Canopy. As shown in the illustrations, a cab or canopy can be furnished for protecting the motorman. The cabs are fully enclosed, and are provided with suitable doors and windows. They may be made of either steel or wood, according to service requirements. The canopies are of sheet steel, and when desired are extended the full length of the locomotive as shown in the illustration on page 15.

Performance, Rating and Dimensions. The table on page 33 gives the performance, rating and principal dimensions of the standard sizes of Baldwin gasoline locomotives.

The average resistance of rolling stock on

Radiator End of Locomotive

Cab End of Locomotive

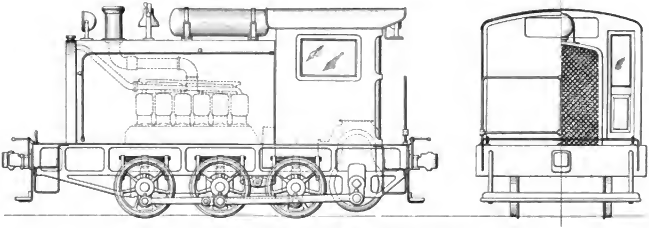
The Gasoline "Old Ironsides." First Baldwin Internal Combustion Locomotive. Still Used by E. I. du Pont de Nemours & Company

industrial railways is about thirty pounds per ton of 2000 pounds hauled. This, however, varies considerably, and in exceptional cases may be as low as seven or as high as sixty pounds per ton, depending upon the condition of tracks and equipment. Assuming or knowing this resistance, the required draw-bar pull on level track may be determined by multiplying this figure by the number of tons to be hauled. For each per cent. of grade there is an additional resistance of twenty pounds per ton, and on curves of short radius there is a further increase. The draw-bar pulls given in the table are for straight and level track. On grades they will be reduced by an amount equivalent to the weight of the locomotive in tons, times twenty pounds for each per cent. of grade.

Specifications and prices covering locomotives suitable for any given service conditions will be gladly furnished upon receipt of the information called for by the data sheet in the back of this catalogue.

Fuel Consumption. Running under normal or rated load, the consumption of gasoline will be about one-tenth of a gallon per horsepower per hour. Observations covering a considerable period in service, indicate that for most requirements the fuel consumption may be based on an average development, throughout the working day, of one-half the rated horsepower of the engine, or even less in some cases.

Locomotive of 3'-0½" Gauge, Used by the Granby Mining & Smelting Company, Granby, Ill.



General Arrangement of Six-coupled, 15 and 25-ton Locomotives

Testing. Every engine is given a thorough block test to determine its horse-power, observe the running qualities and make necessary adjustments.

After the locomotive has been completed it is placed on testing rolls, and run under conditions which approximate those of actual service. As a result, the locomotive is ready for work as soon as it is placed on the tracks of the purchaser.

One of Three Locomotives of Two-feet Gauge, in Use by the Chicago Warehouse and Terminal Company

Performance, Rating and Dimensions

Code Word	Redoutes	Redoutiez	Redoutons	Redraft	Redrafted
Weight of locomotive in pounds	10,000	15,000	20,000	**30,000**	50,000
Rated horse power of motor	35	50	65	**100**	135
Normal speed of motor in R.P.M.	650	650	550	**550**	520
Number of cylinders in motor	4	4	4	**6**	6
Diameter and stroke of cylinders	5" x 7½"	6¼" x 8"	7¼" x 9"	**7¼"x 9"**	7¼" x 12"
Draw bar pull, in pounds, on straight level track at 4 miles per hour	2,400	3,550	4,700	**7,100**	9,400
Draw bar pull, in pounds, on straight level track at 6 miles per hour	1,600	2,300	3,000	**4,600**	6,100
Draw bar pull, in pounds, on straight level track at 12 miles per hour	700	1,000	1,350	**2,100**	2,700
Number of wheels (all wheels driving)	4	4	4	**6**	6
Diameter of driving wheels, in inches	24	26	28	**30**	36
Wheel base	3' 9"	5' 0"	6' 0"	**6' 4"**	8' 0"
Height over cab or canopy	7' 6"	8' 6"	9' 0"	**10' 4"**	11' 0"
Height without cab or canopy	5' 8"	6' 8"	7' 6"	**8' 0"**	....
Length over frames	12' 1"	14' 3"	16' 0"	**18' 4"**	19' 10"
Width over all	....	....	....	....	9' 0"
Minimum gauge in inches for inside frames	36	42	48	**48**	56½
Minimum gauge in inches for outside frames	24	24	24	**36**	....
For width over all with inside frames, add to gauge in inches	22	24	25	**27**	....
For width over all with outside frames, add to gauge in inches	37	39	43	**45**	....
Fuel tank capacity in gallons	25	35	35	**50**	50

The maximum standard speeds for above locomotives are 2, 4, 6 and 12 miles per hour forward and reverse. The draw bar pulls for the 4, 6 and 12 miles per hour speeds are given in above table. The 2 M.P.H. or low speed is for starting under load. All gears are forged steel. All driving springs are semi-elliptic.

The 25-ton locomotive is considered for standard gauge only. Air brakes are standard for the 25-ton locomotives. Other sizes can be furnished with air brakes, if desired, where track gauge is wide enough to permit the application; but these will be considered special and special dimensions and increased weights will be necessary.

General Offices of the Company

500 North Broad Street, Philadelphia

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Chicago, Ill.	Charles Riddell	627 Railway Exchange
St. Louis, Mo.	A. S. Goble	1210 Boatmen's Bank Building
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Pittsburgh, Pa.	E. Converse Peirce	279 Union Arcade Building
Houston, Texas	Paul G. Cheatham	401 Carter Building
St. Paul, Minn.	Henry Blanchard	908 Merchants National Bank Building
San Francisco, Cal.	Williams, Dimond & Co.	310 Sansome Street
Portland, Ore.	A. J. Beuter	312 Northwestern Bank Building
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Brazil	Cory Bros. & Co., Ltd.	Bahia
Brazil	Edward C. Holden	Para
Brazil	MacGregor & Co.	Pernambuco
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China	Andersen, Meyer & Co., Ltd.	Shanghai
Dutch East Indies	J. O. Feenstra	Bandoeng, Java
France	H. A. F. Campbell	Paris, 4 Rue Edouard VII

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500 North Broad Street, Philadelphia

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Japan	Sale & Frazar, Ltd.	Tokio
Mexico	Carl Holt Smith	Mexico City
New South Wales	R. Towns & Co.	Sydney
New Zealand	Philips & Pike	Wellington
Peru	C. R. Cullen	Lima
Poland	Frank W. Morse	Warsaw, Krolewska, 1
Porto Rico and Sto. Domingo	R. Carrion	San Juan, American Colonial Bank Bldg.
Portugal	E. Pinto Basto & Co., Ltd.	Lisbon
Portuguese East Africa	Mann, George & Co., Ltd.	Lourenço Marques, Delagoa Bay
Scandinavia	Olav Belsheim	Christiania, Norway (Toldbogaden, 8)
Southern Africa	F. V. Green	Johannesburg
Spain	H. P. Austin	Madrid, Apartado 473
Venezuela	Kunhardt & Co.	New York, N. Y.
Victoria	Newell & Co.	Melbourne
Western Australia	Leslie & Co.	Perth
West Indies	G. R. Perez	Havana, 520 National Bank of Cuba Bldg.

Internal Combustion Locomotive

Data Sheet

The following data should be completely given in order that we may determine the size of locomotive best suited for the requirements.

1. Date..
2. Inquiry for..................................
3. Location....................................
4. What is the altitude, if over 1000 feet above sea level? ....
5. What is the nature of the service?...............
6. How many hours per day will the locomotive be in service?...................................
7. Exact gauge of track on straight line (inside distance between heads of rails) is......feet.........inches.
8. Is the gauge increased on curves?...............
9. Weight of rail is................pounds per yard.
10. What is the general condition of the track?........
11. What is the length of haul?....................
12. What is the average grade and is it in favor of, or against, the load?............................
13. Maximum grade against the load is............. per cent. for distance of....................feet.
14. Radius of sharpest curve, measured to center of track, is.......................................feet.
15. Length of sharpest curve is.................feet.
16. If curves occur on grades, what curve radius and grade per cent. are in combination?.............
17. Will it be necessary to start the train on grade?....
18. Weight of empty car is..................pounds
19. Weight of loaded car is..................pounds
20. What is the heaviest load to be hauled in tons of ....pounds?
21. State whether tons are American (2000 pounds), English (2240 pounds), or Metric (2204 pounds).....
22. How many cars in one train?...................
23. Are the car wheels loose or tight on axles?.........
24. Do the car journals run in anti-friction (roller or ball) bearings?..............................
25. What is the wheelbase of cars?..................
26. Are the cars of single or double truck type?.......
27. What is the style of car couplings?..............
28. Height of coupling above top of rail is.......inches
29. Should the engine have a closed cab or an open canopy?.....................................
30. Extreme height of engine must not exceed......... feet..................................inches
31. Extreme width of engine must not exceed......... feet..................................inches

REMARKS:..
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Bal

THE BALDWIN LOCOMOTIVE WORKS

RECORD No. 96

LOCOMOTIVES FOR LOGGING SERVICE

THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U.S.A.

Locomotives for Logging Service

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RECORD NO. 96

1920

CODE WORD—REDRARAMOS

Six-Coupled Double-Ender Tank Locomotive in Service, Ostrander Ry. & Timber Co., Ostrander, Washington

Logging Locomotives

RAILWAY motive power is seldom subjected to more severe operating conditions than those found in logging service. Tracks are usually uneven, curves are sharp, and grades are steep; while the locomotives are heavily worked, and must remain in service with a minimum amount of attention and repairs. This requires a machine with a short rigid but relatively long total wheel-base, ample steam generating capacity and details throughout designed to withstand rough service. The type of direct-connected locomotive best fitted for meeting these conditions is one having a two-wheeled radial truck at each end, the number of pairs of driving-wheels depending upon the weight necessary for adhesion, and the amount that can be safely carried by each pair of wheels. The trucks guide the locomotive into curves and switches when running in either direction, and also protect the driving tires against flange wear; and the equalization system is so arranged that the weight is evenly distributed, while each wheel finds a bearing when passing over rough tracks. As a result, the locomotive is easy on the track and road-bed, and derailment seldom occurs, even under most unfavorable conditions.

For average service conditions, the weight required for adhesion can be carried on three pairs of driving-wheels; and the 2-6-2 type is specially successful in logging service. Where an engine with this wheel arrangement will not afford sufficient capacity, the 2-8-2, or Mikado type, should be used. A locomotive with a separate tender is usually preferred, especially where a haul of any length must be made from the woods to the mill.

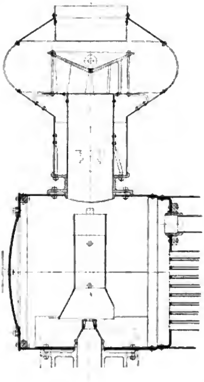
Several of the locomotives illustrated are designed to use superheated steam, and the use of the superheater is becoming common on logging locomotives. Under favorable conditions, the superheater effects a material reduction in fuel and water consumption, and increases the horse-power capacity of the locomotive. A careful study should be made of operating conditions, however, before deciding whether a superheater shall be applied.

An effective spark-arrester is an absolute essential on a logging locomotive, especially if wood is used for

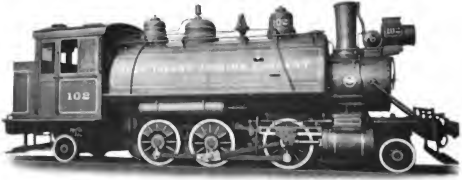
fuel. The Rushton stack, which is shown in the accompanying drawing, is recommended as the most effective spark-arrester in use. The lower section of the stack is double, with an outer casing surrounding the inside pipe. Above the top of this pipe is placed an inverted cast-iron cone, having involute deflectors on its under side. These deflectors churn and break up the sparks, imparting to them a rotary motion as they pass through the balloon-shaped casing, which encloses the cone. The central section of this casing is of cast iron, a material having excellent wear-resisting qualities; while the upper and lower sections are of pressed steel or copper when specified, and are duplicates of each other. The sparks, while being thrown around within the casing, are broken up and extinguished. The heavier particles fall into the annular space surrounding the inside pipe, and are removed through suitable hand-holes. In order to catch the lighter particles, a flange of netting, open in the center to provide a free draft, is interposed in the path of the sparks.

This stack is built in various sizes and, in combination with suitable smoke-box fittings, can readily be applied to existing wood-burning locomotives whose spark-arresting equipment is defective.

The Rushton stack is also satisfactory with coal fuel; and it provides an excellent equipment where coal and wood are used alternately, as no change need be made in the smoke-box fittings.



SIX-COUPLED DOUBLE-ENDER LOCOMOTIVE IN SERVICE, NORFOLK LUMBER CO., WALLACE, NORTH CAROLINA



Six-Coupled Tank Locomotive

Class 10-28-¼-D, 59 — for the — Gauge 4′ 8½″

Deer Island Logging Co., Deer Island, Oregon

GENERAL DIMENSIONS

CYLINDERS

Diameter	17″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Straight
Diameter	50″
Thickness of sheets	⅝″
Working pressure	165 lbs.
Fuel	Oil
Firebox—Material	Steel
Staying	Radial
Length	60 7/16″
Width	34¼″
Depth, front	57⅛″
Depth, back	53″
Thickness of sheets—Sides	⅜″
Back	5/16″
Crown	⅜″
Tube	½″
Water Space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	152
Length	13′ 6½″
Heating Surface—Firebox	80 sq. ft.
Tubes	1071 sq. ft.
Total	1151 sq. ft.
Grate area	14.4 sq. ft.

DRIVING WHEELS

Diameter, outside	44″
Diameter, center	38″
Journals	7″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	4¼″ x 7½″
Diameter, back	28″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	10′ 0″
Rigid	10′ 0″
Total engine	25′ 9″

WEIGHT, ESTIMATED

On driving wheels	91,000 lbs.
On truck, front	11,000 lbs.
On truck, back	16,000 lbs.
Total engine	118,000 lbs.
Tank capacity, water	1600 U. S. gals.
Tank capacity, oil	550 U. S. gals.

SERVICE CONDITIONS

Curves	25 degrees
Grades	5 per cent.
Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine:

On a level	2430 tons
" ½ per cent. grade	1170 tons
" 1 " " "	730 tons
" 2 " " "	400 tons
" 3 " " "	265 tons
" 4 " " "	190 tons
" 5 " " "	145 tons
" 6 " " "	110 tons


20
S. S. & S. RY.

Six-Coupled Double-Ender Type Locomotive

Class 10-18-¼-D, 37 — for the — Gauge 3′ 0″

Surry Lumber Company
Dendron, Surry County, Virginia

GENERAL DIMENSIONS

CYLINDERS

Diameter	12″
Stroke	18″
Valves	Balanced slide

BOILER

Type	Extended wagon top
Diameter	38″
Thickness of barrel sheets	5/16″
Working pressure	170 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Staying	Radial
Length	51″
Width	37⅜″
Depth, front	45½″
Depth, back	37¼″
Thickness of sheets—Sides	⅜″
Back	5/16″
Crown	⅜″
Tube	½″
Water space—Front	3½″
Sides	2½″
Back	2½″

Tubes—Diameter	2″
Material	Steel
Thickness	No. 12 W. G.
Number	81
Length	11′ 6″
Heating Surface—Firebox	50 sq. ft.
Tubes	484 sq. ft.
Total	534 sq. ft.
Grate area	13.2 sq. ft.

DRIVING WHEELS

Diameter, outside	37″
Diameter, center	32″
Journals	5″ x 6″

ENGINE TRUCK WHEELS

Diameter, front	24″
Journals	3½″ x 6″
Diameter, back	24″
Journals	3½″ x 6″

WHEEL BASE

Driving	7′ 9″
Rigid	7′ 9″
Total engine	20′ 9″
Total engine and tender	40′ 1¼″

WEIGHT

On driving wheels	39,800 lbs.
On truck, front	7,750 lbs.
On truck, back	8,900 lbs.
Total engine	56,450 lbs.
Total engine and tender	92,500 lbs.

TENDER

Wheels, number	8
Wheels, diameter	26″
Journals	3¼″ x 6″
Tank capacity	1700 U. S. gals.
Fuel "	4 tons

SERVICE CONDITIONS

Grades	4 per cent.

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	1045 tons
" ½ per cent. grade	490 tons
" 1 " " "	300 tons
" 2 " " "	155 tons
" 3 " " "	95 tons
" 4 " " "	60 tons
" 5 " " "	40 tons
" 6 " " "	25 tons


A. E. BELL
A. E. BELL

Six-Coupled Double-Ender Type Locomotive

Class 10-18-¼-D, 31 for Gauge 4′ 8½″

A. E. Bell, Lois Springs, Alabama

GENERAL DIMENSIONS

CYLINDERS

Diameter	12″
Stroke	18″
Valves	Balanced slide

BOILER

Type	Wagon-top
Diameter	40″
Thickness of sheets	$\frac{7}{16}$″
Working pressure	180 lbs.
Fuel	Wood
Firebox—Material	Steel
Staying	Radial
Length	$55\frac{11}{16}$″
Width	34¼″
Depth, front	48″
Depth, back	40¼″
Thickness of sheets—Sides	⅜″
Back	$\frac{5}{16}$″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	90
Length	10′ 6″
Heating Surface—Firebox	60 sq. ft.
Tubes	491 sq. ft.
Total	551 sq. ft.
Grate area	13.3 sq. ft.

DRIVING WHEELS

Diameter, outside	36″
Diameter, center	31″
Journals	5½″ x 7″

ENGINE TRUCK WHEELS

Diameter, front	24″
Journals	4″ x 6½″
Diameter, back	24″
Journals	4″ x 6½″

WHEEL BASE

Driving	8′ 0″
Rigid	8′ 0″
Total engine	21′ 4″
Total engine and tender	40′ 9″

WEIGHT

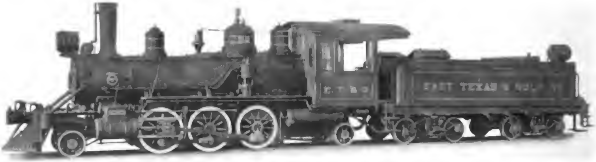
On driving wheels	43,550 lbs.
On truck, front	8,250 lbs.
On truck, back	9,000 lbs.
Total engine	60,800 lbs.
Total engine and tender about	107,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	24″
Journals	3¾″ x 7″
Tank capacity	2000 U. S. gals.
Fuel capacity	2 cords

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	1170 tons
" ½ per cent. grade	550 tons
" 1 " " "	335 tons
" 2 " " "	170 tons
" 3 " " "	105 tons
" 4 " " "	70 tons
" 5 " " "	45 tons
" 6 " " "	30 tons


EAST TEXAS & GULF RY.

Six-Coupled Double-Ender Type Locomotive

Class 10-20-¼-D, 27 — for the — Gauge 4' 8½"

Lodwick Lumber Company, Hicksbaugh, Texas

GENERAL DIMENSIONS

CYLINDERS

Diameter	13"
Stroke	22"
Valves	Balanced slide

BOILER

Type	Extended wagon top
Diameter	44"
Thickness of sheets	$\frac{7}{16}$", and ½"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Staying	Radial
Length	55$\frac{13}{16}$"
Width	34⅜"
Depth, front	56"
Depth, back	54¾"
Thickness of sheets—Sides	$\frac{5}{16}$"
Back	$\frac{3}{16}$"
Crown	⅜"
Tube	½"
Water space—Front	4"
Sides	3"
Back	3"

Tubes—Diameter	2"
Material	Steel
Thickness	No. 12 W. G.
Number	116
Length	11' 6"
Heating Surface—Firebox	74 sq. ft.
Tubes	693 sq. ft.
Total	767 sq. ft.
Grate area	13.3 sq. ft.

DRIVING WHEELS

Diameter, outside	44"
Diameter, center	38"
Journals	5½" x 8"

ENGINE TRUCK WHEELS

Diameter, front	24"
Journals	4½" x 8"
Diameter, back	24"
Journals	4½" x 8"

WHEEL BASE

Driving	8' 0"
Rigid	8' 0"
Total engine	22' 9"
Total engine and tender	46' 1"

WEIGHT, ESTIMATED

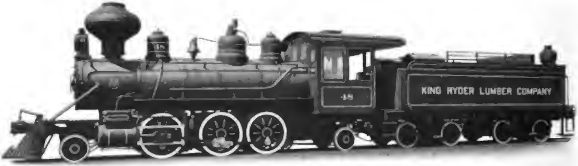
On driving wheels	57,500 lbs.
On truck, front	10,500 lbs.
On truck, back	11,000 lbs.
Total engine	79,000 lbs.
Total engine and tender	139,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	28"
Journals	3¾" x 7"
Tank capacity	3000 U. S. gals.
Fuel "	5 tons

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	1390 tons
" ½ per cent. grade	650 tons
" 1 " "	390 tons
" 2 " "	200 tons
" 3 " "	120 tons
" 4 " "	75 tons
" 5 " "	50 tons
" 6 " "	30 tons


KING RYDER LUMBER COMPANY
48

Six-Coupled Double-Ender Type Locomotive

Class 10-24-1/4-D, 123 — for the — Gauge 4' 8½"

King Ryder Lumber Co., Bonami, Louisiana

GENERAL DIMENSIONS

CYLINDERS

Diameter	15"
Stroke	20"
Valves	Balanced slide

BOILER

Type	Straight top
Diameter	50"
Thickness of sheets	½"
Working pressure	180 lbs.
Fuel	Wood
Firebox—Material	Steel
Staying	Radial
Length	59 3/16"
Width	33¼"
Depth, front	59¼"
Depth, back	57¼"
Thickness of sheets—Sides	3/8"
Back	5/16"
Crown	3/8"
Tube	½"
Water space—Front	4"
Sides	3"
Back	3"

Tubes—Diameter	2"
Material	Iron
Thickness	No. 12 W. G.
Number	147
Length	11' 10½"
Heating Surface—Firebox	83 sq. ft.
Tubes	908 sq. ft.
Total	991 sq. ft.
Grate area	13.7 sq. ft.

DRIVING WHEELS

Diameter, outside	46"
Diameter, center	40"
Journals	6" x 8"

ENGINE TRUCK WHEELS

Diameter, front	26"
Journals	4¼" x 7½"
Diameter, back	26"
Journals	4¼" x 7½"

WHEEL BASE

Driving	9' 2"
Rigid	9' 2"
Total engine	23' 9"
Total engine and tender	47' 11¼"

WEIGHT

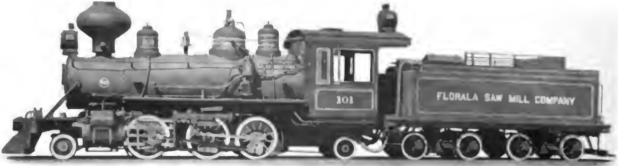
On driving wheels	62,000 lbs.
On truck, front	10,500 lbs.
On truck, back	11,500 lbs.
Total engine	84,000 lbs.
Total engine and tender,	about 164,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	30"
Journals	4¼" x 8"
Tank capacity	4000 U. S. gals.
Fuel capacity	3½ cords

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	1610 tons
" ½ per cent. grade	750 tons
" 1 " " "	455 tons
" 2 " " "	230 tons
" 3 " " "	140 tons
" 4 " " "	90 tons
" 5 " " "	55 tons
" 6 " " "	35 tons


101
FLORALA SAW MILL COMPANY

Six-Coupled Double-Ender Type Locomotive

Class 10-24-¼-D, 125 for the Gauge 4′ 8½″

Florala Saw Mill Co., Paxton, Walton County, Florida

GENERAL DIMENSIONS

CYLINDERS

Diameter	15″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Extended wagon top
Diameter	52″
Thickness of sheets	9/16″
Working pressure	180 lbs.
Fuel	Wood
Firebox—Material	Steel
Staying	Radial
Length	59 3/16″
Width	34⅜″
Depth, front	60¾″
Depth, back	58″
Thickness of sheets—Sides	5/16″
Back	5/16″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Steel
Thickness	No. 12 W. G.
Number	160
Length	11′ 10½″
Heating Surface—Firebox	86 sq. ft.
Tubes	988 sq. ft.
Total	1074 sq. ft.
Grate area	14.1 sq. ft.

DRIVING WHEELS

Diameter, outside	44″
Diameter, center	38″
Journals	6″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	24″
Journals	4¼″ x 7½″
Diameter, back	24″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	9′ 2″
Rigid	9′ 2″
Total engine	23′ 9″
Total engine and tender	45′ 6¾″

WEIGHT

On driving wheels	67,800 lbs.
On truck, front	11,950 lbs.
On truck, back	12,200 lbs.
Total engine	91,950 lbs.
Total engine and tender	161,950 lbs.

TENDER

Wheels, number	8
Wheels, diameter	30″
Journals	4¼″ x 8″
Tank capacity	3500 U. S. gals.
Fuel capacity	3 cords

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	1825 tons
" ½ per cent. grade	855 tons
" 1 " " "	525 tons
" 2 " " "	270 tons
" 3 " " "	165 tons
" 4 " " "	110 tons
" 5 " " "	75 tons
" 6 " " "	50 tons


208
D. Q. & E.

Six-Coupled Double-Ender Type Locomotive

Class 10-26-¼-D, 147 for the Gauge 4′ 8½″

Texas, Oklahoma & Eastern Railroad, De Queen, Arkansas

GENERAL DIMENSIONS

CYLINDERS

Diameter	16″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Wagon-top
Diameter	52″
Thickness of sheets	½″ and $\frac{9}{16}$″
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Staying	Radial
Length	54¾″
Width	54¼″
Depth, front	59″
Depth, back	53½″
Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3½″
Back	3″

Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	178
Length	14′ 9″
Heating Surface—Firebox	88 sq. ft.
Tubes	1367 sq. ft.
Firebrick tubes	11 sq. ft.
Total	1466 sq. ft.
Grate area	20.6 sq. ft.

DRIVING WHEELS

Diameter, outside	46″
Diameter, center	40″
Journals	7″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	4¼″ x 7½″
Diameter, back	28″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	10′ 0″
Rigid	10′ 0″
Total engine	26′ 0″
Total engine and tender	47′ 3″

WEIGHT

On driving wheels	76,300 lbs.
On truck, front	12,800 lbs.
On truck, back	14,100 lbs.
Total engine	103,200 lbs.
Total engine and tender	about 170,000 lbs.

TENDER

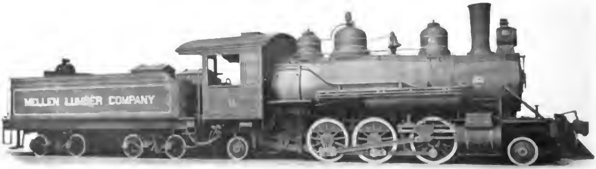
Wheels, number	8
Wheels, diameter	33″
Journals	3¾″ x 7″
Tank capacity	3000 U. S. gals.
Fuel capacity	6 tons

SERVICE CONDITIONS

Curves	30 degrees
Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2055 tons
" ½ per cent. grade	975 tons
" 1 " " "	600 tons
" 2 " " "	310 tons
" 3 " " "	195 tons
" 4 " " "	130 tons
" 5 " " "	90 tons
" 6 " " "	65 tons


MELLEN LUMBER COMPANY

Six-Coupled Double-Ender Type Locomotive

Class 10-26-¼-D, 145 | for the | Gauge 4′ 8½″

Mellen Lumber Co., Mellen, Wisconsin

GENERAL DIMENSIONS

CYLINDERS

Diameter	16″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Wagon-top
Diameter	56″
Thickness of sheets	9/16″
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Staying	Radial
Length	55 13/16″
Width	41⅞″
Depth, front	59½″
Depth, back	52″
Thickness of sheets—Sides	5/16″
Back	5/16″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	218
Length	12′ 9″
Heating Surface—Firebox	83 sq. ft.
Tubes	1446 sq. ft.
Total	1529 sq. ft.
Grate area	16.3 sq. ft.

DRIVING WHEELS

Diameter, outside	46″
Diameter, center	40″
Journals	7″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	26″
Journals	4¼″ x 7½″
Diameter, back	26″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	9′ 0″
Rigid	9′ 0″
Total engine	24′ 6″
Total engine and tender	48′ 5″

WEIGHT

On driving wheels	80,000 lbs.
On truck, front	10,300 lbs.
On truck, back	10,600 lbs.
Total engine	100,900 lbs.
Total engine and tender about	180,000 lbs.

TENDER

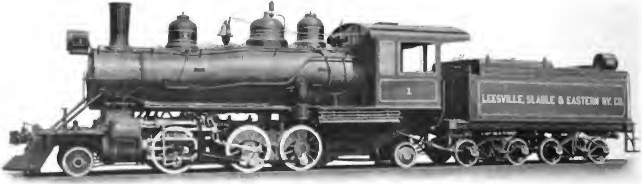
Wheels, number	8
Wheels, diameter	28″
Journals	4¼″ x 8″
Tank capacity	4000 U. S. gals.
Fuel capacity	5 tons

SERVICE CONDITIONS

Curves	16 degrees uncompensated
Grades	3 per cent.
Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2160 tons
" ½ per cent. grade	1020 tons
" 1 " " "	625 tons
" 2 " " "	325 tons
" 3 " " "	205 tons
" 4 " " "	135 tons
" 5 " " "	95 tons
" 6 " " "	65 tons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LEESVILLE, SLAGLE & EASTERN RY. CO.

Six-Coupled Double-Ender Type Locomotive

Class 10-28-1/4-D, 141 for the Gauge 4' 8½"

Leesville, Slagle & Eastern Railway Co., Hawthorne, Louisiana

GENERAL DIMENSIONS

CYLINDERS

Diameter	17"
Stroke	24"
Valves	Balanced slide

BOILER

Type	Extended wagon top
Diameter	56"
Thickness of sheets	5/8" and 11/16"
Working pressure	165 lbs.
Fuel	Oil
Firebox—Material	Steel
Staying	Radial
Length	64 3/16"
Width	42"
Depth, front	63½"
Depth, back	60½"
Thickness of sheets—Sides	3/8"
Back	5/16"
Crown	3/8"
Tube	½"
Water space—Front	4"
Sides	3"
Back	3"

Tubes—Diameter	2"
Material	Steel
Thickness	No. 12 W. G.
Number	200
Length	14' 9"
Heating Surface—Firebox	101 sq. ft.
Tubes	1536 sq. ft.
Total	1637 sq. ft.
Grate area	18.7 sq. ft.

DRIVING WHEELS

Diameter, outside	41"
Diameter, center	38"
Journals	8" x 9"

ENGINE TRUCK WHEELS

Diameter, front	26"
Journals	5" x 10"
Diameter, back	26"
Journals	5" x 10"

WHEEL BASE

Driving	10' 3"
Rigid	10' 3"
Total engine	26' 10"
Total engine and tender	46' 10"

WEIGHT

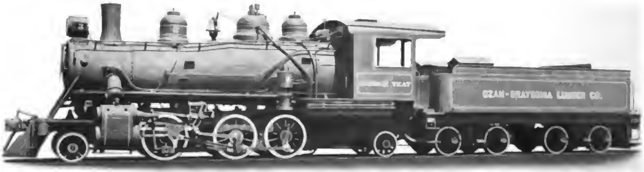
On driving wheels	94,000 lbs.
On truck, front	12,500 lbs.
On truck, back	15,500 lbs.
Total engine	122,000 lbs.
Total engine and tender	196,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	28"
Journals	4¼" x 8"
Tank capacity, water	3500 U. S. gals.
Tank capacity, oil	1500 U. S. gals.

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2400 tons
" ½ per cent. grade	1130 tons
" 1 " " "	690 tons
" 2 " " "	360 tons
" 3 " " "	225 tons
" 4 " " "	150 tons
" 5 " " "	105 tons
" 6 " " "	75 tons



Six-Coupled Double-Ender Type Locomotive

Class 10-28-¼-D, 138 for the Gauge 4' 8½"

Ozan-Graysonia Lumber Co., Prescott, Arkansas

GENERAL DIMENSIONS

CYLINDERS

Diameter	17"
Stroke	24"
Valves	Piston, 9½" diam.

BOILER

Type	Wagon-top
Diameter	56"
Thickness of sheets	⅝" and 11/16"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Material	Steel
Staying	Radial
Length	64⅛"
Width	42"
Depth, front	63½"
Depth, back	60½"
Thickness of sheets—Sides	⅜"
Back	⅜"
Crown	⅜"
Tube	½"
Water space—Front	4"
Sides	3"
Back	3"

Tubes—Diameter	2"
Material	Iron
Thickness	No. 12 W. G.
Number	200
Length	14' 9"
Heating Surface—Firebox	101 sq. ft.
Tubes	1536 sq. ft.
Total	1637 sq. ft.
Grate area	18.7 sq. ft.

DRIVING WHEELS

Diameter, outside	46"
Diameter, center	40"
Journals	8" x 9"

ENGINE TRUCK WHEELS

Diameter, front	28"
Journals	5" x 10"
Diameter, back	28"
Journals	5" x 10"

WHEEL BASE

Driving	10' 3"
Rigid	10' 3"
Total engine	26' 10"
Total engine and tender	50' 8¼"

WEIGHT, ESTIMATED

On driving wheels	96,000 lbs.
On truck, front	13,000 lbs.
On truck, back	16,000 lbs.
Total engine	125,000 lbs.
Total engine and tender	205,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33"
Journals	4¼" x 8"
Tank capacity	4000 U. S. gals.
Fuel capacity	6½ tons

SERVICE CONDITIONS

Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2510 tons
" ½ per cent. grade	1190 tons
" 1 " " "	730 tons
" 2 " " "	380 tons
" 3 " " "	235 tons
" 4 " " "	160 tons
" 5 " " "	110 tons
" 6 " " "	80 tons


EAST OREGON LUMBER COMPANY

Mikado Type Locomotive

Class 12-30-¼-E, 44 | for the | Gauge 4′ 8½″

East Oregon Lumber Co., Enterprise, Oregon

GENERAL DIMENSIONS

CYLINDERS

Diameter	18″
Strok	24″
Valves	Balanced slide

BOILER

Type	Straight
Diameter	70″
Thickness of sheets	11/16″
Working pressure	180 lbs.
Fuel	Wood
Firebox—Material	Steel
Staying	Radial
Length	89 11/16″
Width	41″
Depth, front	67¾″
Depth, back	58¾″
Thickness of sheets—Sides	⅜″
Back	5/16″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	291
Length	13′ 0″
Heating Surface—Firebox	140 sq. ft.
Tubes	1968 sq. ft.
Total	2108 sq. ft.
Grate area	25.5 sq. ft.

DRIVING WHEELS

Diameter, outside	44″
Diameter, center	38″
Journals	7½″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	4¼″ x 7½″
Diameter, back	28″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	12′ 1″
Rigid	12′ 1″
Total engine	27′ 3″
Total engine and tender	49′ 11½″

WEIGHT, ESTIMATED

On driving wheels	111,000 lbs.
On truck, front	15,000 lbs.
On truck, back	13,000 lbs.
Total engine	139,000 lbs.
Total engine and tender	220,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	28″
Journals	4¼″ x 8″
Tank capacity	4000 U. S. gals.
Fuel capacity	4½ cords

SERVICE CONDITIONS

Curves	25 degrees
Grades	6 per cent.
Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2930 tons
" ½ per cent. grade	1400 tons
" 1 " " "	860 tons
" 2 " " "	455 tons
" 3 " " "	285 tons
" 4 " " "	195 tons
" 5 " " "	140 tons
" 6 " " "	100 tons


11
11
FROST-JOHNSON LUMBER CO.

Mikado Type Locomotive

Class 12-30-¼-E, 45 | for the | Gauge 4′ 8½″

Frost-Johnson Lumber Co., Montrose, Louisiana

GENERAL DIMENSIONS

CYLINDERS

Diameter	18″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Straight top
Diameter	70″
Thickness of sheets	11/16″
Working pressure	180 lbs.
Fuel	Oil
Firebox—Material	Steel
Staying	Radial
Length	89 11/16″
Width	41″
Depth, front	68″
Depth, back	62″
Thickness of sheets—Sides	3/8″
Back	3/16″
Crown	3/8″
Tube	½″
Water space—Front	4″
Sides	3″
Back	3″

Tubes—Diameter	2″
Material	Steel
Thickness	No. 12 W. G.
Number	291
Length	13′ 0″
Heating Surface—Firebox	143 sq. ft.
Tubes	1968 sq. ft.
Total	2111 sq. ft.
Grate area	25.5 sq. ft.

DRIVING WHEELS

Diameter, outside	44″
Diameter, center	37″
Journals	7½″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	4¼″ x 7½″
Diameter, back	28″
Journals	4¼″ x 7½″

WHEEL BASE

Driving	12′ 1″
Rigid	12′ 1″
Total engine	27′ 3″
Total engine and tender	51′ 11½″

WEIGHT

On driving wheels	113,050 lbs.
On truck, front	15,900 lbs.
On truck, back	14,450 lbs.
Total engine	143,400 lbs.
Total engine and tender	about 233,400 lbs.

TENDER

Wheels, number	8
Wheels, diameter	30″
Journals	5″ x 9″
Tank capacity water	4500 U. S. gals.
Tank capacity oil	2000 U. S. gals.

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	2925 tons
" ½ per cent. grade	1390 tons
" 1 " " "	850 tons
" 2 " " "	445 tons
" 3 " " "	280 tons
" 4 " " "	190 tons
" 5 " " "	130 tons
" 6 " " "	95 tons


SNOQUALMIE FALLS LUMBER COMPANY
1

Mikado Type Locomotive

Class 12-30-$\frac{1}{4}$-E, 42 — for the — Gauge 4′ 8$\frac{1}{2}$″

Snoqualmie Falls Lumber Co., Snoqualmie Falls, Washington

GENERAL DIMENSIONS

CYLINDERS

Diameter	18″
Stroke	24″
Valves	Balanced slide

BOILER

Type	Straight
Diameter	70″
Thickness of sheets	$\frac{11}{16}$″
Working pressure	180 lbs.
Fuel	Oil
FIREBOX—Material	Steel
Staying	Radial
Length	89$\frac{11}{16}$″
Width	41″
Depth, front	67$\frac{3}{4}$″
Depth, back	59$\frac{3}{4}$″
Thickness of sheets—Sides	$\frac{3}{8}$″
Back	$\frac{5}{16}$″
Crown	$\frac{3}{8}$″
Tube	$\frac{1}{2}$″
Water space—Front	4″
Sides	3″
Back	3″
TUBES—Diameter	2″
Material	Iron
Thickness	No. 11 W. G.
Number	291
Length	13′ 0″

HEATING SURFACE—Firebox	140 sq. ft.
Tubes	1968 sq. ft.
Total	2108 sq. ft.
Grate area	25.5 sq. ft.

DRIVING WHEELS

Diameter, outside	44″
Diameter, center	38″
Journals	7$\frac{1}{2}$″ x 8″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	4$\frac{1}{4}$″ x 7$\frac{1}{2}$″
Diameter, back	28″
Journals	4$\frac{1}{4}$″ x 7$\frac{1}{2}$″

WHEEL BASE

Driving	12′ 1″
Rigid	12′ 1″
Total engine	27′ 3″
Total engine and tender	49′ 1$\frac{1}{2}$″

WEIGHT

On driving wheels	113,400 lbs.
On truck, front	15,400 lbs.
On truck, back	12,000 lbs.
Total engine	140,800 lbs.
Total engine and tender	about 210,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	28″
Journals	5″ x 9″
Tank capacity, water	3500 U. S. gals.
Tank capacity, oil	1600 U. S. gals.

SERVICE CONDITIONS

Curves . . . 20 degrees compensated

Grades, 3 per cent in favor of load with a maximum grade of 6 per cent on spurs.

Rails . . . 56 and 60 lbs. per yard

HAULING CAPACITY in tons of 2000 lbs., exclusive of engine and tender:

On a level	2940 tons
" $\frac{1}{2}$ per cent. grade	1305 tons
" 1 " " "	865 tons
" 2 " " "	460 tons
" 3 " " "	290 tons
" 4 " " "	200 tons
" 5 " " "	145 tons
" 6 " " "	105 tons

Mikado Type Locomotive

Class 12-34-¼-E, 40 — for the — Gauge 4′ 8½″

Arizona Lumber & Timber Co., Flagstaff, Arizona

GENERAL DIMENSIONS

CYLINDERS

Diameter	20″
Stroke	28″
Valves	Piston, 12″ diam.

BOILER

Type	Straight
Diameter	74″
Thickness of sheets	¾″
Working pressure	170 lbs.
Fuel	Oil
Firebox—Material	Steel
Staying	Radial
Length	90¾″
Width	66″
Depth, front	68¼″
Depth, back	65¼″
Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	⅜″
Tube	½″
Water space—Front	4″
Sides	3½″
Back	3½″
Tubes—Diameter	2″
Material	Iron
Thickness	No. 12 W. G.
Number	350
Length	16′ 6″

Heating Surface—Firebox	158 sq. ft.
Tubes	3008 sq. ft.
Total	3166 sq. ft.
Grate area	41.3 sq. ft.

DRIVING WHEELS

Diameter, outside	48″
Diameter, center	42″
Journals, main	9″ x 10″
Journals, others	8½″ x 10″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	6″ x 10″
Diameter, back	36″
Journals	6″ x 11″

WHEEL BASE

Driving	13′ 0″
Rigid	13′ 0″
Total engine	27′ 10″
Total engine and tender	58′ 6″

WEIGHT

On driving wheels	134,600 lbs.
On truck, front	15,200 lbs.
On truck, back	24,200 lbs.
Total engine	174,000 lbs.
Total engine and tender about	285,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	33″
Journals	5″ x 9″
Tank capacity, water	5500 U. S. gals.
Tank capacity, oil	2000 U. S. gals.

SERVICE CONDITIONS

Curves	20 degrees uncompensated
Grades	3 per cent.
Rails	56 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	3650 tons
" ½ per cent. grade	1725 tons
" 1 " " "	1060 tons
" 2 " " "	555 tons
" 3 " " "	350 tons
" 4 " " "	240 tons
" 5 " " "	170 tons
" 6 " " "	120 tons


HUMBIRD LUMBER COMPANY

Mikado Type Locomotive

for the

Humbird Lumber Co., Sandpoint, Idaho

Class 12-34-¼-E, 42   Gauge 4′ 8½″

GENERAL DIMENSIONS

CYLINDERS

Diameter	20½″
Stroke	28″
Valves	Piston, 12″ diam.

BOILER

Type	Straight
Diameter	74″
Thickness of sheets	¾″
Working pressure	160 lbs.
Fuel	Soft coal
FIREBOX—Material	Steel
Staying	Radial
Length	90⅛″
Width	66″
Depth, front	68¼″
Depth, back	64″
Thickness of sheets—Sides	⅜″
Back	⅜″
Crown	½″
Tube	½″
Water space—Front	4″
Sides	3½″
Back	3½″

TUBES—Diameter	5⅜″ and 2″
Material	5⅜″, steel 2″, iron
Thickness	5⅜″, No. 9 W. G. 2″, No. 12 W. G.
Number	5⅜″, 28; 2″, 199
Length	16′ 3″
HEATING SURFACE—Firebox	154 sq. ft.
Tubes	2322 sq. ft.
Firebrick tubes	24 sq. ft.
Total	2500 sq. ft.
Superheater	553 sq. ft.
Grate area	41.3 sq. ft.

DRIVING WHEELS

Diameter, outside	48″
Diameter, center	42″
Journals, main	9″ x 10″
Journals, others	8½″ x 10″

ENGINE TRUCK WHEELS

Diameter, front	28″
Journals	6″ x 10″
Diameter, back	36″
Journals	6″ x 10″

WHEEL BASE

Driving	13′ 1″
Rigid	13′ 1″
Total engine	27′ 1″
Total engine and tender	55′ 4½″

WEIGHT

On driving wheels	138,300 lbs.
On truck, front	15,800 lbs.
On truck, back	23,300 lbs.
Total engine	177,400 lbs.
Total engine and tender about	270,000 lbs.

TENDER

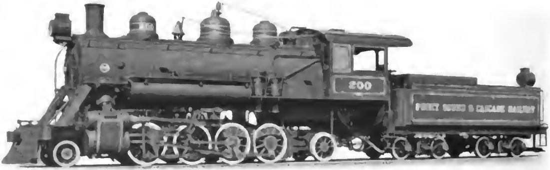
Wheels, number	8
Wheels, diameter	30″
Journals	5″ x 9″
Tank capacity	4500 U. S. gals.
Fuel capacity	8 tons

SERVICE CONDITIONS

Curves	18 degrees on main line, 30 degrees on spurs
Grades	3½ per cent. on main line, 5 per cent. on spurs
Rails	56 lbs. per yard

HAULING CAPACITY in tons of 2000 lbs., exclusive of engine and tender:

On a level	3620 tons
" ½ per cent. grade	1715 tons
" 1 " " "	1055 tons
" 2 " " "	560 tons
" 3 " " "	355 tons
" 4 " " "	240 tons
" 5 " " "	170 tons
" 6 " " "	125 tons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Mikado Type Locomotive

Class 12-34-1/4-E, 43 | for the | Gauge 4' 8½"

Clear Lake Lumber Co., Clear Lake, Washington

GENERAL DIMENSIONS

CYLINDERS

Diameter	20½"
Stroke	28"
Valves	Piston, 12" diam.

BOILER

Type	Straight
Diameter	74"
Thickness of sheets	¾"
Working pressure	160 lbs.
Fuel	Oil
Firebox—Material	Steel
Staying	Radial
Length	90 3/16"
Width	66"
Depth, front	68¼"
Depth, back	64"
Thickness of sheets—Sides	3/8"
Back	5/16"
Crown	3/8"
Tube	½"
Water space—Front	4"
Sides	3½"
Back	3½"

Tubes—Diameter	5 3/8" and 2"
Material	5 3/8", steel 2", iron
Thickness	5 3/8", No. 9 W. G. 2", No. 12 W. G.
Number	5 3/8", 28; 2", 199
Length	16' 3"
Heating Surface—Firebox	154 sq. ft.
Tubes	2322 sq. ft.
Total	2476 sq. ft.
Superheater	553 sq. ft.
Grate area	41.3 sq. ft.

DRIVING WHEELS

Diameter, outside	48"
Diameter, center	42"
Journals, main	9" x 10"
Journals, others	8½" x 10"

ENGINE TRUCK WHEELS

Diameter, front	28"
Journals	6" x 10"
Diameter, back	36"
Journals	6" x 10"

WHEEL BASE

Driving	13' 1"
Rigid	13' 1"
Total engine	27' 1"
Total engine and tender	55' 4½"

WEIGHT, ESTIMATED

On driving wheels	141,500 lbs.
On truck, front	15,500 lbs.
On truck, back	22,000 lbs.
Total engine	179,000 lbs.
Total engine and tender	270,000 lbs.

TENDER

Wheels, number	8
Wheels, diameter	30"
Journals	5" x 9"
Tank capacity, water	4500 U. S. gals.
Tank capacity, oil	2000 U. S. gals.

SERVICE CONDITIONS

Curves	25 degrees
Grades	2 per cent
Rails	56 and 60 lbs. per yard

Hauling Capacity in tons of 2000 lbs., exclusive of engine and tender:

On a level	3620 tons
" ½ per cent. grade	1715 tons
" 1 " " "	1055 tons
" 2 " " "	560 tons
" 3 " " "	355 tons
" 4 " " "	240 tons
" 5 " " "	170 tons
" 6 " " "	125 tons

General Offices of the Company

500 North Broad Street, Philadelphia

REPRESENTATIVES AND AGENTS

New York, N. Y.	Richard Sanderson	120 Broadway
Chicago, Ill.	Charles Riddell	627 Railway Exchange
St. Louis, Mo.	A. S. Goble	1210 Boatmen's Bank Building
Richmond, Va.	G. F. Jones	407 Travelers Building
Pittsburgh, Pa.	E. Converse Peirce	279 Union Arcade Bldg.
Houston, Texas	Paul G. Cheatham	401 Carter Building
St. Paul, Minn.	Henry Blanchard	908 Merchants National Bank Building
San Francisco, Cal.	Williams, Dimond & Co.	310 Sansome Street
Portland, Ore.	A. J. Beuter	312 Northwestern Bank Building
Argentine Republic	Wallace R. Lee	Buenos Aires, Paseo Colon, 185
Balkan States	E. St. J. Greble	Bucharest, Roumania
Brazil	C. H. Crawford	Rio de Janeiro, Rua Alfandega, 5
Brazil	Cory Bros. & Co., Ltd.	Bahia
Brazil	Edward C. Holden	Para
Brazil	Monteath & Co.	Pernambuco
Chile	Wessel, Duval & Co.	Valparaiso
China	Andersen, Meyer & Co., Ltd.	Shanghai
Dutch East Indies	J. O. Feenstra	Bandoeng, Java

General Offices of the Company

500 North Broad Street, Philadelphia

REPRESENTATIVES AND AGENTS

France	H. A. F. Campbell	Paris, 4 Rue Edouard VII
Great Britain	R. P. C. Sanderson	London, 34 Victoria St., S. W. 1.
Hawaiian Islands	C. Brewer & Co., Ltd.	Honolulu
Japan	Sale & Frazar, Ltd.	Tokio
Mexico	Carl Holt Smith	Mexico City
New South Wales	R. Towns & Co.	Sydney
New Zealand	Philips & Pike	Wellington
Peru	C. R. Cullen	Lima
Poland	Frank W. Morse	Warsaw, Krolewska, 1
Porto Rico and Santo Domingo	R. Carrion	San Juan, American Colonial Bank Bldg.
Portugal	E. Pinto Basto & Co., Ltd.	Lisbon
Port. East Africa	Mann, George & Co., Ltd.	Lourenco Marques, Delagoa Bay
Scandinavia	Olav Belsheim	Christiania, Norway (Toldbogaden, 8)
Southern Africa	F. V. Green	Johannesburg
Spain	H. P. Austin	Madrid, Apartado 473
Victoria	Newell & Co.	Melbourne
Western Australia	Leslie & Co.	Perth
West Indies	G. R. Pérez	Havana, 520 National Bank of Cuba Bldg.

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THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA., U. S. A.

The Portable Boats of Early Railroad Practice

By J. SNOWDEN BELL

Record No. 97

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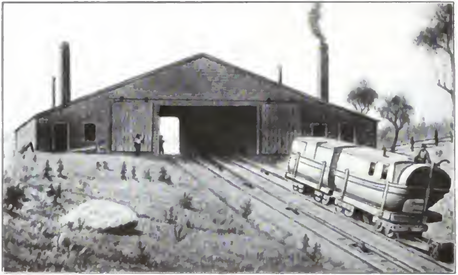


A Sectional Boat Ascending One of the Inclined Planes on the Allegheny Portage Railroad.

The Portable Boats of Early Railroad Practice

By J. Snowden Bell

IT WILL be a matter of surprise, not merely to the general reader, but as well to most persons familiar with the operation of railroads, to know that many years ago, the transportation of freight and passengers between the cities of Philadelphia and Pittsburgh was largely and successfully conducted in *canal boats,* which traversed the entire distance between these terminals, partly by railroad and partly by canal. There are but few persons now living who, like the writer, have seen these boats in service, and the data as to their origin and development, and their railroad transportation equipment, is so meagre and so scattered that a record of it, while merely a matter of history, may be found also to be of sufficient interest to warrant its presentation.

What was known as the Main Line of the Public Works of the State of Pennsylvania, extending from Philadelphia to Pittsburgh, and aggregating 394.6 miles, was constructed by the State and completed in March, 1834. It was for a number of years—that is, until June, 1857, when it was sold to the Pennsylvania Railroad Company—operated by the State, under the control of a board known as the Canal Commissioners. It comprised a line of double track railroad from Philadelphia to Columbia, 81.6 miles; a canal from Columbia to Hollidaysburg, 172 miles; the Allegheny Portage Railroad, crossing the Allegheny Mountains and extending from Hollidaysburg to Johnstown, 36.6 miles; and a canal from Johnstown to Pittsburgh, 104 miles. Horses were the first motive power on both these lines of railroad, but were soon superseded by locomotives, and mules were always used for haulage on the canals. As noted in Wood's *Practical Treatise on Railroads,* 2nd Edition, 1832, "This Railroad is therefore the first which was undertaken in any part of the world by a government."

The boats used in this system of combined land and water transportation, which were generally termed "portable" boats, will be first considered, and be followed by general notes of the equipment by which, in their earlier service, they were carried over the railroad sections of the route.

I. The Portable Boats

The transfer of boats from one level of a canal to another, upon carriages running on inclined planes, instead of floating them through locks, of course involved, broadly speaking, their movement both on land and in water. This was a well-known practice long prior to the operation of the Pennsylvania public works system, and is even said to have been practiced by the ancients, who did not appear to have known of canal locks. An illustration appears in Stevenson's *Sketch of Civil Engineering in North America*, 1838, of a boat and "boat car" used on the Morris Canal of New Jersey, which the author states was "the only canal in America in which the boats are moved from different levels by means of inclined planes instead of locks." This prior practice, however, has obviously no bearing derogatory to the merit and novelty of the Pennsylvania portable boats.

The initial step in the transportation of boats over the railroad tracks of the Pennsylvania public works—which, however, was not on a *commercial* scale—or by the use of sectional boats, is recorded in Day's *Historical Collections of the State of Pennsylvania*, Philadelphia, 1843 (p. 184), as quoted from a prior publication, which is not named, as follows:

> "In October, 1834, this portage [the Allegheny Portage Railroad] was actually the means of connecting the waters of Eastern Pennsylvania with those of Mississippi; and as the circumstance is peculiarly interesting, we here place it on record. Jesse Chrisman, from the Lackawanna, a tributary of the north branch of the Susquehanna, loaded his boat, named *Hit or Miss*, with his wife, children, beds and family accommodations, with pigeons and other livestock, and started for Illinois. At Hollidaysburg, where he expected to sell his boat, it was suggested by John Dougherty, of the Reliance Transportation Line, that the whole concern could be safely hoisted over the mountain and set afloat again in the canal. Mr. Dougherty prepared a railroad car calculated to bear the novel burden. The boat was taken from its proper element and placed on wheels, and under the superintendence of Major C. Williams

(who, be it remembered, was the first man who ran a boat over the Allegheny Mountains) the boat and cargo at noon on the same day began their progress over the rugged Allegheny. All this was done without disturbing the family arrangements of cooking, sleeping, etc. They rested at night on the top of the mountain, like Noah's ark on Ararat, and descended next morning into the valley of the Mississippi, and sailed for St. Louis."

The author of the *Historical Collections,* referring to the conditions of operation when he wrote, adds:

"The trip of a boat over the mountain is now no novel sight, except that instead of going over whole, they are so constructed as to be separated into three or four parts on reaching the railroad. After thus mounting the cars piecemeal, with their loads of emigrants, baggage and freight on board, they wend their way over the mountains, and resuming their proper element at Johnstown, they unite their parts again and glide on to the waters of the great west."

The earliest record of the idea of constructing a canal boat in separate sections for transportation over a portage between two lines of canal, appears in a report on a survey of the Juniata route, made by Canvass White, a civil engineer, to the Canal Commissioners of Pennsylvania, which is printed on page 83 *et seq* of the Commissioners' Report dated February 7th, 1827. In this report, Mr. White says:

"I made a partial examination of the country over which the railway must pass, and from the general appearance, I think the ground is favorably situated, considering the formidable barrier interposed between the eastern and western waters. A good turnpike road would probably answer all the purposes of transportation for several years, and a part of the bed could be occupied by the railway whenever the business should require its construction. I would suggest the idea of making the canal boats in three or four pieces, to be divided transversely, and transported over the portage without changing the cargo."

The credit of the invention of means for operating on a commercial scale, transportation of freight and passengers, without unloading and reloading or transferring, over a route comprising both canals and railroads, is due to John Elgar, a civil engineer of Baltimore, Md. After having devised and patented other appliances relating to railroads, a Patent of the United States was granted to him on November 7th, 1835, for what he designated as

"certain improvements in the art of, and in the apparatus for the conveyance or transportation of goods, on a line where canals and railroads form alternate links in the chain of communication, as for example, on the great Pennsylvania line from Philadelphia to Pittsburgh."

While this Patent is later by about thirteen months than the date when the small boat *Hit or Miss* was carried over the Allegheny Portage Railroad, as before noted, and while that railroad transfer from one canal to another may, perhaps, have suggested Elgar's invention, that invention is none the less meritorious, by reason of its inauguration of a commercially valuable practice on an extended scale.

Fig. 1, which is a reduced reproduction of the drawing of the Elgar Patent, is apparently the earliest representation of a sectional canal boat anywhere recorded, and the principle of the Elgar invention, upon which the subsequent practice on the Main Line of the Pennsylvania public works was based, is fully and clearly stated in the specification of the Patent, as follows:

"The object which I have in view, in the first instance, is to prevent the necessity of removing the goods from the vehicle within which they are first loaded by constructing cases which serve on railroads as car bodies, and on canals as boats. This I effect by making such vehicles, or car bodies, of sheet iron, in the manner of iron tanks, riveting them up water-tight in the same way. The dimensions of these bodies must be determined by that of the canal locks through which they are to pass when used as boats. If, for example, the lock will admit a boat of fourteen feet in width, and eighty in length, the bodies may be made seven feet wide and twenty feet long, so that eight bodies, two abreast, and four in length, may

Fig. 1

pass at the same time. I intend sometimes to make the bodies wholly of sheet iron, but they may be made of that material to the height of about three feet only, with an additional height, say of three feet, made of wood. The bodies when made of this length are to be carried upon eight-wheeled cars. If four-wheeled cars are preferred, the bodies must be made of a length suitable thereto, and a greater number of them will then, of course, be connected together when in the water.

"As these bodies are, by their combination, to form canal boats, the requisite number of them are to be so formed at one end as to constitute a well-shaped bow, and the same number are to be so shaped as to constitute a stern; the other ends are to be made square, so that when connected by proper fastenings they will be in one continuous inflexible line, to the length of the lock through which they are to pass."

On February 24, 1843, Patent No. 2973 was granted to John Dougherty, of Hollidaysburg, Pa., who was doubtless the constructor of the car on which the *Hit or Miss* was carried over the Allegheny Portage Railroad, in October, 1834, as before noted. The specification states the invention to be "certain improvements in the apparatus for the transportation of goods on canals and railroads; said improvements consisting in a more perfectly carrying out of the method of transportation for which Letters Patent of the United States were granted to John Elgar, dated on the 7th day of November, 1835, and of which I am the assignee for the State of Pennsylvania."

Fig. 8 of the Dougherty Patent is stated in the specification to be a side view of a four-section boat, and Fig. 9, a top view of a double series of sections, bolted or keyed together, but the sheet containing these views cannot be found in the Patent Office, having unfortunately been lost or accidently destroyed. The general features of the design may, however, be understood from the following excerpt from the specification:

"The boats, or boxes, may be made of sheet metal, or of wood; or their lower portions may be of metal, and their upper of wood; the invention not being in any way dependent upon the kind of material employed. I connect these boats, or boxes, together, when they are used on canals, in such manner as that there shall be two sections in width, and three, or more, in length. In this respect, my plan of connecting the sections is not the same with that adopted by Mr. John Elgar, who proposed to connect them

in a continuous line, and in such manner as that they should possess a certain degree of flexibility at the places where they were joined to each other; but when so joined, they have not been found to operate well, as they cannot be kept with their sides and bottoms coincident, but vary laterally, as well as upward and downward; from which cause they are liable to be injured by snags, or rocks, and have their motion retarded by the water. A still more frequent difficulty resulting from the original mode of connecting them has arisen from the want of a free passage of the towing lines from end to end of the boat; all of which objections I obviate by attaching to the fore end of each section, which is to have a rear section joined to it, a plate of iron, six or eight inches, more or less, in width, and of such length as that it shall extend entirely across the under part of the section, from side to side, and sufficiently high on each side to confine the two parts, or sections, in place. Such plates are to be bent so as to conform to the curvature of the bottom; are to be fastened to one of the segments by bolts, or otherwise, and to project over and form a ledge, say two-thirds, more or less, of their width, so that the rear section may be received and rest upon it. The sections are then to be firmly secured end to end, by loops and keys, or in some analogous mode, until the intended length is obtained; and two such series of sections are to be secured by

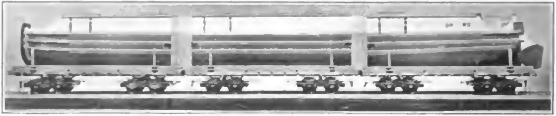


Fig. 2

bolts, bars, or clasps, side by side, and are thus to constitute a combined boat, of the ordinary width of a canal boat, and in length adapted to the locks through which they are to pass."

An extended search has failed to develop any drawing illustrating the structural details of the sectional boats as actually built and operated, and the recollection of the few now living who have seen them, is so much impaired by the long lapse of years as not to be fully reliable. Their characteristic features may, however, be sufficiently understood by reference to Fig. 2, which represents the sectional boat "Pathfinder," a model of which formed part of the Exhibit of the Pennsylvania Railroad Co., at the Chicago Exposition, in connection with the following description, which is given by Capt. H. A. Walters, of Lewistown, Pa., who, in 1849, started as a driver on the Pennsylvania canal.

"These [the sectional boats] were 82 feet in length, 13 feet in width, and in depth 12 feet, and were divided into four sections, each 20½ feet long; the boats were round on the bottom and not flat. The sections were fastened together by irons about half way down the side—the iron projected out from the one section into a V-shaped iron on the other section, then a T iron fitted down through both of these irons and locked them together. One section was placed upon one railroad truck which was a little bit longer than the section—say about 23 to 24 feet, and had four wheels. . . . The trucks were round in the bottom to fit the boat's sections."

Capt. Walters' statement of the width of the boats is manifestly erroneous, as they could not, for the reason hereafter stated, have been in excess of about seven feet nine inches in width. This is also indicated in the frontispiece, which is reproduced from an illustration in the Philadelphia Commercial Museum, and represents the stern section, and an intermediate section of a boat, loaded on the so-called "trucks," ascending an inclined plane on the Allegheny Portage Railroad, to be delivered to a locomotive at the summit.

II. The Railroad Hauling Equipment

(a) The Transporting "Trucks"

In transporting the sectional boats over the railroad divisions of the Main Line of the Public Works of Pennsylvania, each section was loaded upon an eight-wheeled car, known as a "truck," although it was fitted with two four-wheeled trucks, one at each end, and the trucks were

coupled up in a train which was hauled over the railroad divisions by a locomotive. On arriving at the canal terminal of a division, the trucks were lowered into the canal, and the sections of the boats were coupled together and hauled through the canal to the next railroad division by horses. The writer has, when a boy, seen sections of these boats, on their trucks, being loaded in a forwarding house or private freight station at Eighth and Market Streets, Philadelphia, from which they were hauled by horses to the Willow Street Railroad, over which the trucks were hauled a few miles by a locomotive to the inclined plane at Belmont, on the Schuylkill River, and thence by a locomotive to the canal at Columbia, Pa.

The only illustration of these flat cars or so-called "trucks," which has been developed, or which it is probable is now in existence, is that which appears in the drawing of the Dougherty Patent before referred to, three of the views of which are here reproduced, as Fig 3, a plan view of the car body; Fig. 4, a side view, and Fig. 5, an end view. The four-wheeled trucks, not involving any departure from the ordinary practice at their date, are not here shown.

The description of the car, given in the specification of the Patent, is as follows:

"In constructing the cradle it is necessary to limit its width to about eight feet nine inches; the passing along the road forbidding that this width should be exceeded; it is necessary, also, that the cars should be capable of running upon curves of fifty or sixty feet radius. The truck wheels which I use are about two feet nine inches in diameter, and instead of being kept to the level of the upper sides of the side pieces of the truck frame, as formerly, they are allowed to rise about a foot above them."

The drawing of the Patent does not show side stakes, or any other means for holding the boat section in position on the cradle, and if the stakes were used, as would appear to be the case, the width of the boat section would probably not be greater than about seven feet nine inches, in view of the limitation of clearance before mentioned.

The specification further says that:

"The longitudinal timber, B, B, may in this case be a foot in depth; and the width of the space, A, A, must be such as, but need not be greater than, will admit of the trucks adapting themselves to the curves of fifty or sixty feet radius, as above named. The trucks work on centre bolts, *a*, *a*, as usual. The cross timbers, C, C, of the cradle, are on their upper

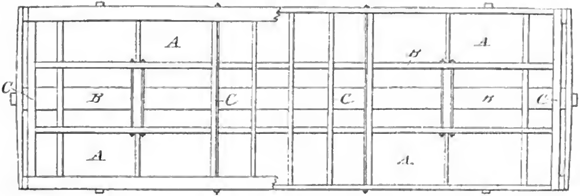


Fig. 3

Fig. 4

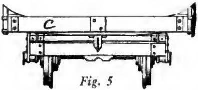


Fig. 5

sides, adapted to the form of the bottom of the boat."

(b) The Early Locomotive Power

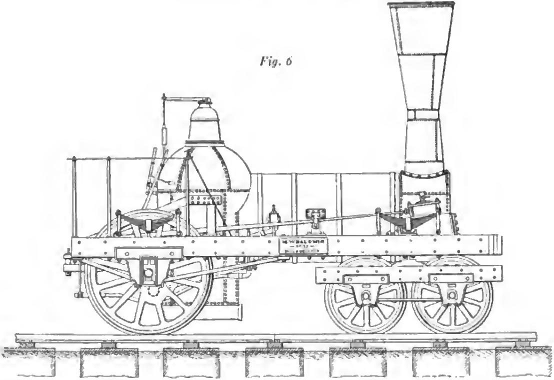
The Canal Commissioners, under whose control, as before stated, the connected system of railroads and canals over which the sectional boats were run was operated, were authorized by an Act of the Pennsylvania Legislature, approved April 15, 1834, to use locomotive engines as motive power, which theretofore had been horses. In pursuance of this authorization, they ordered a number of locomotives from the works of M. W. Baldwin, of Philadelphia, the first of which, the "Lancaster," was put in service on the Philadelphia & Columbia R. R., June 28, 1834, and the second, the "Columbia," September 10, 1834.

The "Lancaster," which is shown in Fig. 6, weighed seventeen thousand pounds and had cylinders 9 x 16, and driving wheels 54 inches in diameter. The "Columbia" was of the same weight and dimensions. It is shown by the records that the "Lancaster" hauled a train of nineteen burden cars over the heaviest grades between Philadelphia and Columbia, which was characterized at that time by the officers of the road as an "unprecedented performance." The weight of these locomotives was in excess of that which was estimated by the Canal Commissioners to be within the capacity of the rails of the Philadelphia & Columbia Railroad, as, in their Report of December 7, 1833, they say: "The *Wiggan* [English] rail, weighing forty-one and a fourth pounds per yard, has been adopted for both tracks of the sixty miles now in progress. It is calculated for carrying locomotive engines weighing six tons." The weight of the Baldwin locomotives was not, however, found to be objectionable, and the reports of their performance were, in all particulars, satisfactory.

In his report to the Board of Canal Commissioners, of November 7, 1834, Mr. Edward F. Gay, Principal Engineer, referring to the engines "Lancaster" and "Columbia," says:

> "Indeed, these engines are justly considered superior and beautiful specimens of mechanism, and reflect great credit on the ingenious mechanic (M. W. Baldwin, Esq., of Philadelphia), who constructed them. They are each supported on six wheels, which is found to be the only arrrangement that will enable a locomotive engine to overcome the severe curves connected with the high grades upon this road without injury to the engine or railway."

Fig. 6



In the same report these engines are further referred to as follows:

"As all the engines preparing for the road are designed to be of the same class, the following statement of the capacity of the 'Lancaster' may be applied to the others.

"Weight of engine, 8 tons; capable of drawing 36 tons, exclusive of cars—say, 56 tons gross. Amount taken at each load limited to 30 tons, or about 48 tons gross. Running time between the inclined planes (77 miles) with the above load, eight hours, including stoppages.

"Expenses of the Trip

"20 bushels coke at 20 cents	$4.00
1½ cords wood at $4.00	6.00
Engineer and attendants	4.00
Oil	.60
Total	$14.60"

Eight more locomotives, all of the same general design as the "Lancaster" and "Columbia," were built by Mr. Baldwin for the State up to the close of the year 1835, these being the "Philadelphia," November 26, 1834; "Pennsylvania," January 3, 1835; "Delaware," February 7, 1835; "Susquehanna," March 12, 1835; "Schuylkill," April 1, 1835; "Kentucky," July 14, 1835; "Juniatta," September 5, 1835; and "Brandywine," October 21, 1835.

As shown in Fig. 7, the "Brandywine" differed from the first engines in having outside connections instead of the "half crank" driving axle, and an iron frame instead of a wooden one.

The report of Mr. Gay, the Principal Engineer, rendered November 7, 1834, includes an estimate for "Eighteen locomotive engines and tenders complete, at $6,300 each, $113,400," and in his report of October 30, 1835, which covers all the ten before noted Baldwin locomotives, he says:

"The engines upon this road have generally performed their trips with great regularity; and it affords me pleasure to add that the American engines, delivered within the present year, are capable of doing more work than was estimated in my last report; the most of them, in their ordinary trips, draw a gross load of seventy-five tons. The engine 'Schuylkill' has drawn over the road a gross load of *one hundred tons,* and several others have drawn, over the highest grade, from eighty to ninety tons gross. When the curves and grades upon the road

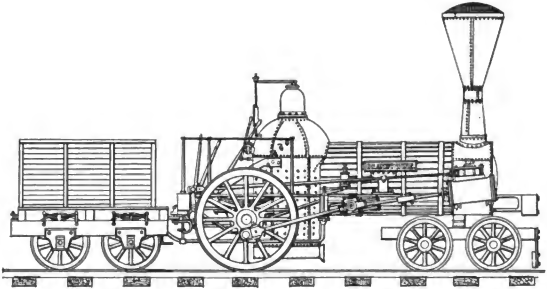


Fig. 7

are taken into consideration, it is believed that the performance of these engines will be found equal to any in America."

The second locomotive that was built by Mr. Baldwin, the "E. L. Miller," which was the immediate predecessor of the "Lancaster," was equipped with a form of traction increaser by which a portion of the weight of the tender could be transferred to the driving wheels of the locomotive, thereby increasing their tractive power. This device was brought out by E. L. Miller, President of the South Carolina Railroad, for which road the engine bearing his name was constructed, and a Patent for it was granted to him, June 19, 1834. As the Miller device was applied on locomotives built for the Canal Commissioners, a description of it may be found of interest in this connection.

Fig. 8 is reproduced from the drawing of the Miller Patent, the specification of which specifies the invention as consisting in "using the tender, or car, next to the engine, for the purpose of adding weight to the driving wheels of the engine at such times only as a greater adhesion is required than the weight would give, which it would be practicable to carry as a fixed weight on those wheels without injury to the road."

The specification describes the construction and manner of operation of the traction increaser in the following terms:

"The mode which I have used, and found to answer perfectly in practice, is simply to connect the car, or tender, next the engine, to the engine by a strong iron bar, or lever, one end of which is bolted to the under side of a cross timber in the frame of the car, or tender, a little back of the centre, and which lever extends under the frame of the tender to the end of the frame of the engine and into the iron which, together with the drawing bolt, secures it to the engine.

"Transversely to this lever, I attach to the end of the tender next the engine, two levers, so that their fulcra shall be six or eight inches on each side of the main lever, or drawing bar.

"These levers have a jaw, or pivot, five or six inches in length, directly over the main lever, and should be about 4½ feet in length.

"When the increased adhesion is wanted, the engineer has only to place his foot upon the ends of these levers and press them into a hook, or groove, for that purpose, on the corner post of the tender;

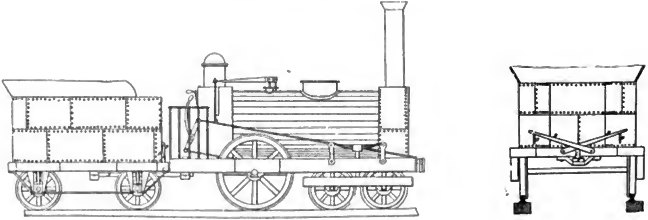


Fig. 8

and a portion of the weight of the car, or tender, next the engine, is thus thrown upon the driving wheels of the engine; and when the increased adhesion is no longer wanted, this weight is detached by simply loosening the ends of the levers."

In his report of October 30, 1835, Mr. Gay notes that the number of engines in service had increased to seventeen, ten of which were manufactured by M. W. Baldwin; five by Robert Stephenson, of England; one by Coleman Sellers & Sons; and one by Long & Norris. Commenting upon the engines, he says:

"The two latter have been but recently put upon the road, and their capacity is not yet fully tested; they are, however, believed to be excellent engines. The engines from Mr. Baldwin have all been tested and found to be of the first class. The five engines

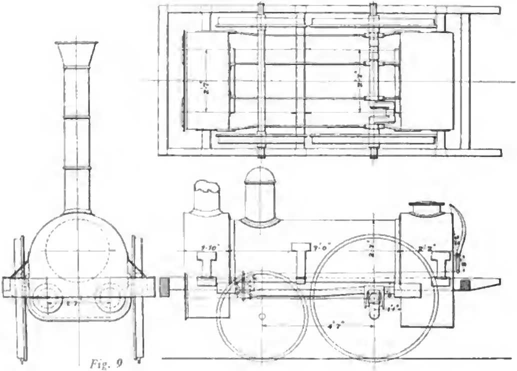


Fig. 9

> imported from England are not as efficient as those manufactured in this country; the workmanship of them is good, but many important parts of the machines are too light to enable them to encounter (with a heavy load) the high grades and severe curves on this railway, in consequence of which frequent repairs are required upon them."

Mr. A. Mehaffey, Superintendent of Motive Power of the Allegheny Portage Railroad division of the line, to which the British engines had probably been transferred, goes much further than Mr. Gay in reporting unfavorably on them. In a report of November 1, 1836, he says:

> "Two of them, viz., the 'John Bull' and 'Red Rover,' both British engines, have recently been sold, and it would have been a saving to the Commonwealth had they been given away for nothing the first day they were placed on the track."

This statement savors so strongly of prejudice as not to be worthy of credence, and the temperate and reasonable criticism of Mr. Gay correctly indicates the reason for the failure of the British engines to give satisfactory results in service. As they were not equipped with trucks, it is obvious that they were not well adapted to traverse the short curves of the line, as also their comparatively light construction, noted by Mr. Gay, impaired their hauling capacity. It does not, however, by any means, necessarily follow that they were either worthless or could not have been used, with reasonable advantage, in lighter service.

The five British engines, which are stated, in Mr. Mehaffey's report, as being the "Albion," "Atlantic," "John Bull," "Fire Fly" and "Red Rover," were built by Robert Stephenson, of Darlington, England, and were all four-wheeled machines, having one pair of driving wheels and one pair of carrying wheels, which were journalled in pedestals rigid with the main frame, and consequently had no capacity of relative radial or lateral motion. Messrs. Robert Stephenson & Co., Ltd., of Darlington, England, have furnished a drawing entitled "Steam Engine No. 54" (builder's number), and a more complete blue print, "Working Drawing of Nos. 110, 112, 113 Locomotives, March 24th, 1835; Nos. 129, 139, March 4th, 1836," together with tables of dimensions of "Locomotives supplied to the United States Railways," and the writer has also received from an English correspondent a copy of a list headed "Locomotives built by Robt. Stephenson & Co. for the U. S. A. between 1831-1836."

purporting to be made up from Wishaw's *Railways of Great Britain and Ireland*, 1st Ed., 1840, Tables 27 and 28, Sec. 2.

From the above data it would appear that in three of the five locomotives built for the Philadelphia & Columbia R. R., the driving and carrying wheels were of the same diameter, and in the other two, the driving wheels were of greater diameter than the carrying wheels. The engines of these two wheel arrrangements are not, however, indicated by name in the lists.

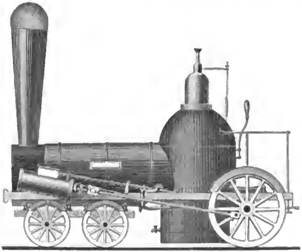


Fig. 10

Fig. 9 is a reduced reproduction of the builder's blue print showing the engines having driving and carrying wheels of different diameters, the dimensions of one of the engines being given as follows: Light weight, 8 tons, 11 cwt.; cylinders, 12 x 18 inches; driving wheels, 5 feet diameter; carrying wheels, 3 feet 6 inches; boiler, 3 feet 4 inches diameter, 8 feet long; firebox, 2 feet 5 inches x 3 feet 2½ inches x 3 feet 5¼ inches; height of chimney above rail, 14 feet 6 inches. These dimensions are not, however, entirely in accord with those appearing in the list from Wishaw's book, in which the cylinders are stated to be 10 x 16 inches. The cylinders of the engines having driving and carrying wheels of equal diameters (4 feet 6 inches) were 10 x 16 inches.

The Principal Engineer's report of October 30, 1835, states, as before noted, that among the seventeen locomotives then in service there was one that was built by Coleman Sellers & Sons, and Mr. Mehaffey's report of November 1, 1836, specifies two, the "America" and "Sampson," as built by C. Sellers & Sons, and first run

September 1, 1836. The only data that has been obtained regarding these engines is that contained in a letter from Mr. Charles Sellers to his brother, Mr. George Escol Sellers, dated July 23, 1884, and a rather crude wood-cut of a locomotive, appearing in an advertisement of Coleman Sellers & Sons, Cardington Iron Works, which is here reproduced as Fig. 10.

The following excerpt from Mr. Sellers' letter contains all that he says which is descriptive of the locomotive:

"Our first locomotive was put on the railroad in 1835. I ran it for one week before we asked the Commissioners to take a trial trip to Lancaster and back.

"It was outside connection, centre-bearing on the truck and iron frame. I recollect great objection was made to the iron frame, as it would not give to the inequalities of the road; all of the English locomotives, and I think two of Baldwin's on the Pennsylvania Railroad, were wooden frames.

* * * * * *

"They [the Commissioners] said that we had to pay Baldwin $500.00 for a Patent attachment to throw part of the weight of the tender on the driving wheels, which we did not use, but that we had put on a Patent attachment of our own to throw part of the weight of the forward end of the engine on the drivers which they thought was much better, as it was self-acting.

"The drawing for the engine must have been made in 1835 (I think earlier, because we had to get the boilers made in New York, and very poorly made at that)."

The traction increaser referred to in this letter was doubtless that of the Patent of C. & G. E. Sellers, May 22, 1835. The principle of the invention is stated to be: "So coupling or connecting the cars containing the load to be drawn to the body of the locomotive engine, as that the load by its action upon a lever or standard shall tend to raise the fore end of the locomotive in any desired degree, and thus to loosen the pressure upon the fore, and transfer the same to the hind wheels." The appliance is very crudely shown and described, and it is not at all clear how the tender or train is to be connected to it, but, if operative, it must have been, as stated in the letter of Mr. Sellers, "self-acting."

The early motive power of the State system also included a locomotive built by Long & Norris, the "Wil-

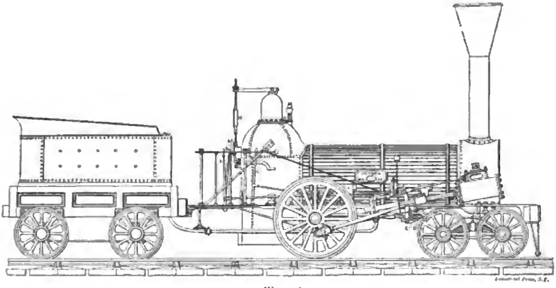


Fig. 11

liam Penn," stated in Mr. Mehaffey's report as having been first run October 14, 1835, and a number of locomotives of the same type, built by William Norris, among which were the "George Washington," "Robert Morris," "Benjamin Franklin" and "Washington County Farmer," which are stated, in the same report, to have been put in service at different dates in the year 1836.

All the locomotives built for the State by William Norris and his successors up to the year 1840, or thereabouts, were of the 4-2-0 type, and were, in all essential particular, similar to that shown in Fig. 11, which represents one of a lot of seventeen constructed by him for the Birmingham & Gloucester Railway, England. They did not materially vary in dimensions from the "William Penn," the weight of which was 23,560 pounds, of which 14,600 pounds were on the driving wheels; cylinders, 10 x 20 inches; driving wheels, 4 feet diameter; boiler, about 14 feet long and 36 inches diameter; grate area, about 9 square feet.

The merits of the respective locations of the driving axle in the Baldwin and the Norris engines, *i. e.*, behind the firebox in the former and in front of it in the latter, were often the subject of discussion during the period that the 4-2-0 type continued to be practically the only one in service. Those who favored the Baldwin arrangement correctly maintained that it gave the engine a longer wheel base and thereby rendered it steadier at high speeds, while the advocates of the Norris design, with equal correctness, pointed out that it increased the adhesion and tractive power of the engine. The advent of the 4-4-0 type rendered the question an academic one, and meanwhile, on the lines of the State system, the Baldwin engines were generally preferred for passenger service and the Norris engines for freight. Both classes undoubtedly gave as efficient service as was possible with their limited capacity, and the reports of the performance of the Norris engines were uniformly favorable. Indeed, the report of J. W. Patton, Superintendent of the Allegheny Portage Railroad, October 31, 1838, went so far as to make the statement (which would seem to be of doubtful correctness), that "Of the locomotives now on this road those made by Mr. William Norris, of Philadelphia, are much superior, doing double the amount of work, with half the quantity of oil and fuel, and not requiring half as much repairs."

All the motive power thus far referred to was constructed in Philadelphia and first put in service on the Philadelphia & Columbia Railroad division of the line,

although some of the locomotives were, from time to time, transferred to the Allegheny Portage Railroad and their places supplied by new ones. For some reason, which is not apparent, the Canal Commissioners placed their orders for locomotives intended for service on the Portage road, in other cities, and on the opening of the road for traffic, in the season of 1835, three locomotives were ready for service on the long level between inclined planes 1 and 2, these being the "Boston," "Delaware" and "Allegheny." The following matter relating to these three engines is taken from the extremely interesting *History of the Pennsylvania Railroad*, by William Bender Wilson, Philadelphia, 1899 (Vol. I, pp. 121-123):

"The 'Boston' was the first locomotive to do service on the Allegheny Portage Railroad. It was built by the Mill Dam Foundry Company, of Boston, Mass., and delivered at Johnstown just before the close of navigation in 1834. It was put in condition during the winter and sent to Pittsburgh to be used as a pattern. It was returned to Johnstown, March 28, 1835. Without water or fuel it weighed 8½ tons. Its cost, exclusive of tender, on the wharf at Boston was $6,996.75. The cost of transportation to the railroad amounted to $223.25. It was put into regular service May 10th, and until November 1, 1835, made its regular trips, covering 52 miles daily, with the exception of 2½ days, when it was laid off for repairs, which cost $17.00. Engineer Welch, in reporting upon its services in the time mentioned, said of it: 'This engine during the greatest part of the season, in connection with its other work, has hauled the passenger cars in both directions each day. This detained it; otherwise it might have made three trips a day for the greater part of the time. It performed the labor every day of eighteen horses, and it might do easily one-third more if it were not necessary to reserve it for the transportation of passengers. The daily expenses of running it is $7.12½, exclusive of repairs.' Its cylinders were 8 inches in diameter, with a 16-inch stroke, whilst its driving wheels were a small pair, 4 feet in diameter, with wooden felloes and spokes. The wheels were tired with iron and were flangeless. During the season of 1835 it was in service 174 days, averaging 52 miles a day distance, and 10 miles per hour speed. Its steam pressure was 125 pounds to the square inch.

"The 'Delaware' and 'Allegheny' were not so satisfactory, and were a source of expense and vexation during the season. They were built by Edward A. G. Young, of New Castle, Del.; reached Hollidaysburg, April 15, 1835, and were sent to Johnstown where the parts were fitted together and the necessary alterations made in an ordinary blacksmith shop, there being no machine shop in operation at the time. Their contract price was $5,500 each, and it cost $158 additional per locomotive to transport them from Philadelphia to Hollidaysburg. Better results were expected of them than from the 'Boston' because the boilers were larger and would generate more steam. The machinery was arranged differently from that of most other engines built upon the same general principles. It was apparently more simple, but less substantial. The builder had had several years' experience in the use of locomotive engines, and it was expected that the deviations made by him from the general plan, and from the engine designated in the contract as the model according to which he was to build for the Portage Railroad, would be an improvement, inasmuch as they were to be put up and tried upon the railroad by persons furnished by the builders and approved of by the engineers before they were finally paid for. The 'Delaware,' after running for four days, broke its crank axle, and had to remain idle until the 1st of September before it was repaired by the contractor. The 'Allegheny,' after considerable refitting, was accepted. It ran about two weeks when its crank axle broke, rendering it useless for the balance of the year. These three locomotives performed all the service they did for the year on the 13-mile level. The 'Pittsburgh,' built upon the plan of the 'Boston,' was constructed by McClurg, Wade & Co., at Pittsburgh, at a cost of $4,500, and was delivered on the road on September 3, 1835."

On page 127 of the same volume there is given the following description of the performance of a locomotive which had been ordered for the Philadelphia & Columbia Railroad, and was tested on its way thereto on the Portage road:

"It was during this year [1836] that a question of what power should be used on the Hollidaysburg level, that had been agitated for some time, was settled. As the steepest grade on that level was fifty-two feet to the mile, there was a great diver-

sity of opinion as to the ability of a locomotive engine to work on the level. The authorities had contracted March 24, 1836, with McClurg, Wade & Co., of Pittsburgh, for the construction of a locomotive named the 'Backwoodsman,' for use on the Columbia & Philadelphia Railroad, and as that machine was ready for delivery, the Board of Canal Commissioners ordered that it be delayed en route to be experimented with on the level. Arriving there in the latter part of September, it was worked under the charge of Messrs. Bridges and Whitney for several days, and proved that locomotives could be used with ease and economy there. At the first trial it arrived at the Hollidaysburg scales from the foot of plane 10 in eleven minutes, hauling eight heavy bloom cars. Its next trip, with thirteen heavily laden cars, occupied twelve minutes."

The report of J. Snodgrass, Superintendent of Motive Power of the Allegheny Portage Railroad, who took charge February 15, 1839, states that there were then seventeen locomotives on that road, the largest portion of which had been used on the Columbia road previous to 1835. These included nine built by William Norris; one, the "Boston," by R. M. Houton; three, the "Allegheny," "Delaware" and "Comet," by E. A. G. Young; and four, the "Backwoodsman," "Mountaineer," "Conemaugh" and "Pittsburgh," by McClurg, Wade & Co., of Pittsburgh, Pa.

Development of the inefficient and wasteful management, and demoralizing results of improper exertion of political influences, which, in the view of the writer, are characteristic of government ownership, began almost upon the inception of the operation of the Main Line of the Public Works of Pennsylvania thereunder. A recital of details would be foreign to the purpose, and beyond the permissible compass of the present paper, but an instance is presented in the explosion of the boiler of the engine "Bush Hill," on the Allegheny Portage Railroad, April 23, 1847, a report of which was made June 10, 1847, to the Committee of Science and Arts of the Franklin Institute, Philadelphia, by Mr. Edward Miller, a civil engineer of the Pennsylvania Railroad. This report is published in the *Journal of the Franklin Institute*, Whole No. Vol. XLIV, 1847 (pp. 69-71), and being believed to be specially interesting, it is here reproduced in full, attention being particularly called to the italics, which are those of Mr. Miller, and to his concluding paragraph:

"JOHN C. CRESSON, ESQ.,

Chairman of Committee on Science and the Arts,
Franklin Institute.

"Dear Sir:—Upon the day I passed over the Allegheny Portage Railroad, April 23rd, 1847, one of the locomotive engines attached to a freight train exploded, killing the engine driver and injuring severely two other persons. I could not, at the time, obtain a correct statement of the facts, as business required me to proceed the same night to Pittsburgh. Being at Johnstown on the 4th inst., I had an opportunity of examining the wreck and enquiring into the facts connected with the explosion, which I now send you, to be laid before your committee, if you consider them of sufficient importance.

"The locomotive 'Bush Hill' was built by Messrs. Norris, and put on the Columbia Railroad April 17th, 1837. In the fall of the same year it was transferred to the Portage, where it has since been in constant use. It was a six-wheeled engine, weighing 12 tons, being one of the heaviest on the road, used the adhesion of two wheels, and was considered one of the best machines on the Portage. It was generally used as a freight engine, but had been running on the 13-mile level for some days prior to the morning of the accident, with the passenger train.

"On that day the steam was raised by the fireman before breakfast, with the expectation that the 'Bush Hill' would have to take the passenger train; but the regular passenger engine, which had been undergoing repairs in the Johnstown shops, arrived and took its place. But for this change the loss of life might have been much greater.

"The fireman, John B. Davis, states that he tried the gauge-cocks before going to his breakfast and found the water above the upper cock. He also tried them after breakfast, before the engine started, and found a full head of water.

"The engineer of the 'Bush Hill,' James Patterson, had gone down to Johnstown the night before to ask that another person might be sent to run his engine, as he wished to attend a funeral. James Barron was accordingly sent up with him by the passenger line in the morning to Incline Plane No. 1; but, as the funeral was to take place at the half-way house, it was concluded that Patterson should run the engine that far, Barron accompanying him. The 'Bush Hill' was attached to a freight train, and

after proceeding about one-quarter of a mile exploded, killing Patterson and wounding Barron and Davis badly.

"The only part of the boiler which gave way was the forward flue-sheet, the upper part of which was torn from the flanch by which it was riveted to the boiler, as far down as the upper row of copper flues, which were also torn loose. The remaining flues, and the whole cylindrical part of the boiler, together with the dome and fire-box, sustained no injury from the explosion. The rent followed strictly the angle of the flanch, without starting a rivet. The rush of steam forward threw the engine entirely over, and it fell backward, bending the platform against the dome, and crushing the tender and one of the cars. The working gear was much bent and broken.

"The flue-sheet was made of two plates, riveted together; the lower one, through which the flues passed, being of three-eighths of an inch iron, and the upper, one-quarter inch. The upper plate was strengthened originally by two stay-bars, both of which were broken off, their fractures showing that they had given way long before. No signs of want of water, nor of overheating, appeared in the flues, fire-box or any part of the boiler.

"The angle of the flanch of the flue-sheet where the rent occurred was probably injured originally in the bending, as a very bad flaw extends not only around the fractured part, but also around the portion below the flues, which was not injured by the explosion. I have sent two portions of the flanch, by Mr. Power, to the Institute, from which this will be apparent.

"Mr. James Bowstad, the foreman of the Johnstown shops, says *he noticed last winter that the flue-sheets of several of the locomotives, including the 'Bush Hill,' were sprung*, and he believes that in all these cases the stay-bars are broken. The other engines which are in this condition are in daily use on the road, and they are unable to repair them, because there are no spare engines to supply their place. He considered the 'Bush Hill' in good order in all other respects. He says that he examined it the day before the accident, in order to ascertain whether a new patch which had been put on the dome leaked. The steam was then high, but it did not leak of any consequence. James Barron states

that when he and Patterson got on the engine the steam was escaping rapidly from this patch, and he thought it too high, for *it was very blue.* He did not, however, at the time, consider it dangerous. Neither Barron nor Davis knew anything about the condition of the safety-valve, and they have no recollection of hearing the steam blowing off at the valve.

"Mr. Power, the Superintendent of the road, believes that the valve was screwed down by somebody while the fireman was at breakfast, during which time the engine stood on the track, fired up and waiting for the train, with nobody to look after it. This is, however, mere surmise; the injury to the valve preventing any conclusions as to its condition. The safety-valve was two inches in diameter, and the scale of the spring-balance would not indicate a greater pressure than 130 pounds to the square inch if screwed down as far as it would go.

"In conclusion, I will remark that the cause of this accident is more manifest than in any explosion I have had occasion to investigate; the evident flaw at the flanch of the flue-sheet, and the fracture of the stay-bars rendering an explosion almost inevitable, if any accident or carelessness should produce an unusual head of steam.

"What can be said of the policy which compels the use of locomotives in such a condition as this? for there is good reason to believe that several others are in the same dangerous state. The number of these machines on the Portage is entirely insufficient to convey the traffic upon it with economy and safety; all of them have been many years in use, and many of them are engines which had been used on the Columbia road until antiquated before being transferred to the Portage.

"Very respectfully,

"EDWARD MILLER, C. E.

"Pittsburgh, Pa., June 10th, 1847."

A resolution of the Board of Canal Commissioners, dated June 2nd, 1838, directed that two engines be fitted to the use of anthracite coal as soon as practicable, pursuant to which a series of experiments was commenced, which were stated by A. Mehaffey, Superintendent, Philadelphia & Columbia Railroad, in his report of that year, to have "produced the most gratifying result." The plan first tested was "to attach a fan to the front of the boiler of one of the locomotives, and thus create a draft. This,

together with some trifling alterations in the engines, promised, in theory, to answer a good end, but when brought into practice was found insufficient to keep up the fire at all times and under all circumstances, as the fan could be put in requisition only when the locomotive itself was in motion." This having failed, the Master Mechanic, Mr. Brandt, suggested placing a fan of a different construction, immediately in front of the ash pan, and driving it by a separate engine. An application of this arrangement was accordingly made, the engine having a cylinder of a 4-inch bore and 8-inch stroke and being placed on the left side of the boiler.

The performance of the locomotive thus equipped was, according to the report, very satisfactory, stress being laid upon the fact that the blower was available whether the locomotive was standing or moving. The report makes the following statement as to the performance of the locomotive, the name or builder of which is not, however, mentioned:

> "The quantity of coal consumed from one plane to the other (distance seventy-seven miles) with a train of twenty or twenty-five loaded cars, is about one and a half tons, at four and a half dollars per ton, retail price. A train of the same weight would require two cords of oak wood, the average price for which, cut and split ready for the engine, is four and a half dollars a cord, thus showing a gain in favor of the coal, thirty-three per cent. Besides, coal enough can be loaded on the tank at Columbia, to carry the train to Philadelphia, without the loss of time and cost of labor, consequent upon stopping and loading wood about every twelve miles.
>
> * * * * * * * * *
>
> The locomotive above described is now performing her regular work from day to day. Another on the same plan will be ready in the course of ten days."

The Canal Commissioners' report of October 31, 1839, contains that of James Cannon, then Superintendent of Motive Power, in which he mentions the purchase of three locomotives, built by Henry R. Campbell, of Philadelphia, costing, with tenders, $7,500 each, of which he says that they "are machines of the very highest order. They weigh thirteen tons and combine great strength and power with beautiful finish. Their performance has fully equalled all my anticipations." He also refers favorably to two locomotives built by D. H. Dotterer & Co., of Reading, and to the purchase of an engine with vertical boiler, which had been placed on the road nearly a year

before by Ross Winans, a similar engine being daily expected. He then refers to the experiment made by "the late superintendent" (Mr. Mehaffey), in the burning of anthracite coal, as to which he says that it "did not succeed and was abandoned before the undersigned took charge of the road." He then describes the plan in use under his supervision as follows:

"The plan now in use is a very small rotary attached to the bottom of the boiler which is driven by a small quantity of steam taken from the dome. The fan is enclosed in an iron casing from which the air is conducted through a funnel to a perfectly tight iron chest, which encloses the whole of the ash pan. The air being forced into the chest, it is constantly working itself through the fire by the power of its own pressure and thereby keeps up a constant blaze, and an amount of heat equal to all its purposes. This fixture was first tried upon a new engine called the 'James Clarke,' one of Mr. Baldwin's first-class machines. It has been making its regular trips for about six weeks, and as yet has given no sign of a failure. It has drawn very heavy loads at every trip and has done its work with more apparent ease than when wood was used upon it as a fuel. As a test, the coal was weighed one trip. The engine drew twenty-two loaded cars, or one hundred and twenty-one tons, and consumed one ton and a half of coal; and had it been of the purest quality and well selected, the trip could have been made with a ton and a quarter, costing about seven dollars and twenty-five cents, while the same amount of freight, drawn by the same engine, would have required two cords of wood, which, including cording, cutting and splitting, costs about eleven dollars. This coal is from the Pottsville mines, and it is the only anthracite which we have yet found to answer the purpose. I may also state that there is other coal of a similar quality, as convenient or more so, that will probably answer as well upon trial.

"There are now five engines upon the road which are propelled by steam, generated with anthracite exclusively, and it is believed that by the first of January all the heavy engines on the road will be ready to use it.

"Numerous experiments have also been made in the use of bituminous coal. This, when it can be had of a pure quality free from sulphur and in masses large enough to prevent its falling through the grates,

has been found to answer admirably by a very simple alteration of the grate bars. Four engines are now using it exclusively. Two are employed in drawing the day lines of passenger cars, and two on the night lines of passenger and freight cars."

In the Annual Report of the Commissioners, January 15, 1841, Mr. Cameron says that the engine contracted for with Ross Winans is similar in principle to the previous engine, but entirely different in its proportions, and adds: "It is intended exclusively for the transportation of heavy trains of burthen cars. It will haul double the ordinary train, but owing to its great weight, must be run very slowly over the road."

Prior to the above experiments on the Columbia Railroad, anthracite coal is stated to have been burned successfully on the Baltimore & Ohio Railroad, in the "grasshopper" and "crab" engines of Ross Winans, with vertical boilers, the fire-boxes of which did not have a greater area than those of the engines of the Columbia road. In the Winans engines, the fan was operated by a rotary engine worked by the exhaust steam so that they were subject to the objection, noted in Mr. Mehaffey's report, of being inoperative when the engine was standing, although this does not appear to have impaired their performance. In view of the successful results in burning anthracite coal, reported by the two Superintendents of Motive Power of the Columbia road, it is remarkable that the use of this fuel was not continued, but this does not appear to have been done.

The substitution of a motor-operated fan for an exhaust blast, as a means for creating the necessary draft in a locomotive fire-box, which had been practiced prior to the year 1834, has laterly been the subject of consideration by engineers of acknowledged ability in the design of locomotives, and a number of designs for the application of the principle have been proposed. So far as the writer has been able to ascertain, none of these has gone into actual service, but the principle appears to be a correct one, and results of practical value may reasonably be expected from its development.

The haulage of the sectional boats constituted a considerable portion of the service of all the locomotives which have been referred to, and while such haulage also formed part of the service of the larger and more powerful locomotives which superseded them, it was not continued for a very long period in the later engines. The consideration of the original and following early motive

power which has been herein presented, would, therefore, seem to be sufficient in connection with the general subject—sectional boats.

The importance and value of inland navigation upon canals and canalized or deepened rivers has for a long time been fully recognized, and large expenditures, both governmental and private, have been devoted to its development. Economical considerations have determined that the dimensions of vessels most desirably adaptable for service in such navigation, should be such that they would not be capable of haulage over railroad track. It is, consequently, while not impossible, altogether improbable that the system originated in the United States of transferring freight without breaking bulk over a line of alternate links of railroad and canal, will be reproduced in the future. Nevertheless, it is not too much to say that Canvass White's conception, nearly a century ago, of such a system rises to the level of engineering genius; and the practical development of that conception into successful operation by his successors, the leading features of which, so far as information was obtainable, the writer has endeavored to present, evidence those who participated in it to have been sufficiently able and ingenious mechanics, and energetic operators, to merit that a record of their achievements should not be omitted from the pages of historical technical literature.

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The Baldwin Locomotive Works

RECORD No. [illegible]

Locomotives for
Heavy Passenger Service

THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA.

Locomotives for Heavy Passenger Service

OFFICERS

RECORD NO. 98

1920

Code Word—REFABRICES

A Trial Run on the Test Track at the Baldwin Eddystone Plant

Locomotives for Heavy Passenger Service

THE greater part of the heavy express passenger service on American railroads is now being handled by six-coupled locomotives. During the past few years the weights of through passenger trains have increased to such an extent that it is no longer possible to develop the required capacity in locomotives having only two pairs of driving wheels, except where grades are very light and conditions are most favorable; and the building of four-coupled locomotives for heavy passenger service has practically ceased.

A six-coupled locomotive designed for service on first-class track can safely carry sufficient weight on driving wheels to develop a tractive force in excess of 40,000 pounds, without using a ratio of adhesion that is below the limits of good practice.

Two types of six-coupled locomotives are used in passenger service, the Ten-wheeled (4-6-0) and the Pacific (4-6-2). The latter type is preferred for heavy work, as space is available for a firebox of any dimensions required, and the steaming capacity is high in proportion to the adhesion. Such locomotives, with driving wheels exceeding six feet in diameter, have successfully replaced Atlantic (4-4-2) type locomotives in handling some of the fastest trains in this country.

Where service conditions are so severe that Pacific type locomotives cannot develop the required capacity, the Mountain (4-8-2) type is preferably used. This type is also well fitted for heavy passenger service where wheel-loads are limited by track conditions, and locomotives of high tractive force are required. The wheel arrangement of the Mountain type is suitable for fast running, and the boiler power is ample for severe service.

The largest passenger locomotives, when working at full capacity, consume more coal than can be fired by hand; and mechanical stokers are being used, to an increasing extent, in this class of work. The use of superheated steam in heavy passenger service has become practically universal, and all the locomotives illustrated in the following pages are equipped with superheaters.

Ten-Wheeled Locomotive

for the

Georgia Southern and Florida Railway

Code Word—REFACHAIS

Baldwin Class 10-36-D, 622

GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 31,000 lbs.

CYLINDERS	21" x 28"
Valves	Piston, 12" diam.
BOILER—Type	Wagon top
Diameter	67¼"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	107⅛"
Width	66"
Depth, front	70⅝"
Depth, back	54⅝"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 26; 2", 199
Length	15' 0"
BOILER—*Continued*	
Heating Surface—Firebox	168 sq. ft.
Tubes	2100 sq. ft.
Total	2268 sq. ft.
Superheater	462 sq. ft.
Grate area	49 sq. ft.
DRIVING WHEELS—Diameter	68"
Journals, main	10" x 12"
Journals, others	9" x 12"
TRUCK WHEELS—Diameter	33"
Journals	5½" x 10"
WHEEL BASE—Driving	15' 0"
Total engine	25' 11½"
Total engine and tender	61' 4"
WEIGHT—On driving wheels	147,200 lbs.
On truck	45,050 lbs.
Total engine	192,250 lbs.
Total engine and tender	340,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	7500 U. S. gals.
Fuel capacity	12 tons

Ten-Wheeled Locomotive

for the

St. Louis Southwestern Railway

Code Word—REFACHIEZ

Baldwin Class 10-38-D, 191
Railway Company's Class G-O

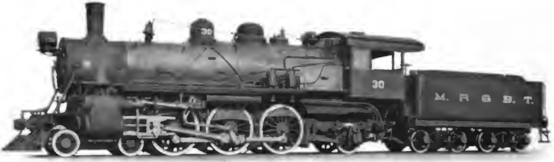
GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 33,400 lbs.

CYLINDERS	22" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	72"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	102"
Width	70"
Depth, front	72"
Depth, back	58¼"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 30; 2", 212
Length	15' 0"

BOILER—*Continued*	
Heating Surface—Firebox	173 sq. ft.
Tubes	2285 sq. ft.
Firebrick tubes	16 sq. ft.
Total	2474 sq. ft.
Superheater	532 sq. ft.
Grate area	49.6 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	10½" x 13"
Journals, others	10" x 13"
TRUCK WHEELS—Diameter	33"
Journals	6" x 12"

WHEEL BASE—Driving	15' 0"
Total engine	26' 2"
Total engine and tender	61' 5¾"
WEIGHT—On driving wheels	165,200 lbs.
On truck	44,200 lbs.
Total engine	209,400 lbs.
Total engine and tender	386,600 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	15 tons



Pacific Type Locomotive

for the

Mississippi River and Bonne Terre Railway

Code Word—REFACHIONS

GENERAL DIMENSIONS

Baldwin Class 12-36-$\frac{1}{4}$-D, 8

Gauge 4' $8\frac{1}{2}$"

Tractive Force, 29,000 lbs.

CYLINDERS	21" x 26"
Valves	Piston, 11" diam.
BOILER—Type	Wagon top
Diameter	64"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	$96\frac{1}{8}$"
Width	$66\frac{1}{4}$"
Depth, front	67"
Depth, back	$59\frac{1}{4}$"
Tubes—Diameter	$5\frac{3}{8}$" and 2"
Number	$5\frac{3}{8}$", 24, 2", 164
Length	19' 0"

BOILER—*Continued*	
Heating Surface—Firebox	154 sq. ft.
Tubes	2263 sq. ft.
Total	2417 sq. ft.
Superheater	558 sq. ft.
Grate area	44.3 sq. ft.
DRIVING WHEELS—Diameter	64"
Journals	9" x 11"
TRUCK WHEELS—Front, diameter	30"
Journals	$5\frac{1}{2}$" x 10"
Back, diameter	40"
Journals	$7\frac{1}{2}$" x 12"
WHEEL BASE—Driving	12' 0"
Total engine	30' 10"
Total engine and tender	56' 4"

WEIGHT—On driving wheels	123,400 lbs.
On truck, front	33,500 lbs.
On truck, back	33,600 lbs.
Total engine	190,500 lbs.
Total engine and tender	290,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5" x 9"
Tank capacity	5000 U. S. gals.
Fuel capacity	10 tons

SERVICE CONDITIONS—Rails 75-90 lbs., curves 12 degrees, maximum grade 1.8 per cent. Curves are not compensated on grades. Sharpest curve on maximum grade 8 degrees.

Pacific Type Locomotive

for the

New Orleans and Northeastern Railroad

Code Word—REFAGOTER

GENERAL DIMENSIONS

Baldwin Class 12-38-¼-D, 379

Gauge 4' 8½"

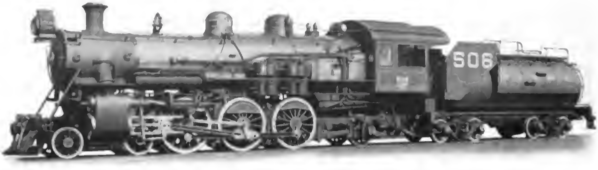
Tractive Force, 33,900 lbs.

CYLINDERS	22" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Straight top
Diameter	66"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length, total	110⅝"
Length of grate	87"
Width	76"
Depth, front	67¼"
Depth, back	59½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 24; 2", 172
Length	19' 3"

BOILER—*Continued*	
Heating Surface—Firebox	171 sq. ft.
Tubes	2373 sq. ft.
Firebrick tubes	29 sq. ft.
Total	2573 sq. ft.
Superheater	546 sq. ft.
Grate area	46 sq. ft.
DRIVING WHEELS—Diameter	68"
Journals, main	9½" x 11"
Journals, others	9" x 11"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 11"
Back, diameter	40"
Journals	7½" x 12"

WHEEL BASE—Driving	12' 0"
Total engine	32' 11"
Total engine and tender	67' 0"
WEIGHT—On driving wheels	140,500 lbs.
On truck, front	44,800 lbs.
On truck, back	32,400 lbs.
Total engine	206,700 lbs.
Total engine and tender	352,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	7500 U. S. gals.
Fuel capacity	14 tons

SERVICE CONDITIONS—Rails, 75 pounds per yard; curves, 6 degrees; grades, 1 per cent.



Pacific Type Locomotive

for the

Nashville, Chattanooga and St. Louis Railway

Code Word—REFAISANT

Baldwin Class 12-40-¼-D, 71
Railway Company's Class K-1-A

Gauge 4' 8½"
Tractive Force, 33,750 lbs.

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Wagon top
Diameter	66"
Working pressure	185 lbs.
Fuel	Soft coal
Firebox—Length	114⅛"
Width	66"
Depth, front	74"
Depth, back	63"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 24; 2", 186
Length	20' 6"
BOILER—*Continued*	
Heating Surface—Firebox	186 sq. ft.
Tubes	2678 sq. ft.
Firebrick tubes	27 sq. ft.
Total	2891 sq. ft.
Superheater	592 sq. ft.
Grate area	52.4 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	10½" x 12"
Journals, others	9½" x 12"
TRUCK WHEELS—Front, diameter	36"
Journals	5½" x 12"
Back, diameter	44"
Journals	8" x 14"
WHEEL BASE—Driving	13' 0"
Total engine	34' 1"
Total engine and tender	69' 4"
WEIGHT—On driving wheels	143,500 lbs.
On truck, front	37,400 lbs.
On truck, back	38,650 lbs.
Total engine	219,550 lbs.
Total engine and tender	375,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8500 U. S. gals.
Fuel capacity	14 tons

Pacific Type Locomotive

for the

Grand Trunk Railway System

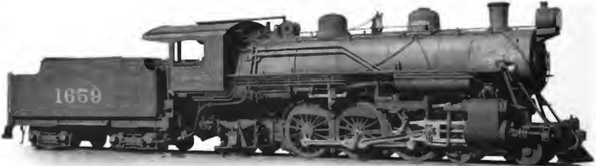
Code Word—REFAISEUR

Baldwin Class 12-40-¼-D, 63
Railway Company's Class P

Gauge 4' 8½"
Tractive Force, 33,800 lbs.

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Straight top
Diameter	70½"
Working pressure	185 lbs.
Fuel	Soft coal
Firebox—Length	96⅛"
Width	75¼"
Depth, front	72¾"
Depth, back	56¼"
Tubes—Diameter	5½" and 2"
Number	5½", 24; 2", 181
Length	20' 7"
BOILER—*Continued*	
Heating Surface—Firebox	163 sq. ft.
Tubes	2635 sq. ft.
Firebrick tubes	28 sq. ft.
Total	2826 sq. ft.
Superheater	592 sq. ft.
Grate area	50.6 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals	9½" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 10½"
Back, diameter	49"
Journals	8" x 14"
WHEEL BASE—Driving	13' 4"
Total engine	33' 2"
Total engine and tender	62' 3½"
WEIGHT—On driving wheels	146,700 lbs.
On truck, front	39,200 lbs.
On truck, back	38,200 lbs.
Total engine	224,100 lbs.
Total engine and tender	375,000 lbs.
TENDER—Wheels, diameter	34"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	10 tons



Pacific Type Locomotive

for the

Central of Georgia Railway

Code Word—REFAIUOLO

Baldwin Class 12-40-¼-D, 67
Railway Company's Class P-69-¼-34.7

Gauge 4' 8½"
Tractive Force, 34,700 lbs

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 12" diam.
BOILER—Type	Straight top
Diameter	70"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length, total	132"
Length of grate	87"
Width	84"
Depth, front	53"
Depth, back	49½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 28; 2", 194
Length	18' 0"
BOILER—*Continued*	
Heating Surface—Firebox	163 sq. ft.
Tubes	2526 sq. ft.
Total	2689 sq. ft.
Superheater	605 sq. ft.
Grate area	50.6 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals	10" x 12"
TRUCK WHEELS—Front, diameter	33½"
Journals	6" x 12"
Back, diameter	48"
Journals	8" x 14"
WHEEL BASE—Driving	12' 0"
Total engine	31' 6"
Total engine and tender	63' 9½"
WEIGHT—On driving wheels	138,000 lbs.
On truck, front	43,800 lbs.
On truck, back	46,800 lbs.
Total engine	228,600 lbs.
Total engine and tender	365,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	7500 U. S. gals.
Fuel capacity	13 tons

Pacific Type Locomotive

for the

Atlantic Coast Line Railroad

Code Word—REFAJO

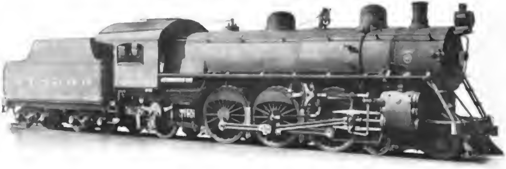
Baldwin Class 12-40-1/4-D, 101
Railroad Company's Class P-4

GENERAL DIMENSIONS

Gauge 4' 8 1/2"
Tractive Force, 37,000 lbs.

CYLINDERS	23" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Conical wagon top
Diameter	76"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	108 1/8"
Width	75 1/4"
Depth, front	82 3/8"
Depth, back	74 1/4"
Tubes—Diameter	5 3/8" and 2"
Number	5 3/8", 36; 2", 227
Length	18' 2"
BOILER—*Continued*	
Heating Surface—Firebox	208 sq. ft.
Combustion chamber	46 sq. ft.
Tubes	3065 sq. ft.
Firebrick tubes	26 sq. ft.
Total	3345 sq. ft.
Superheater	792 sq. ft.
Grate area	56.5 sq. ft.
DRIVING WHEELS—Diameter	68"
Journals, main	10 1/2" x 20"
Journals, others	9 1/2" x 12"
TRUCK WHEELS—Front, diameter	31 3/8"
Journals	6" x 10 1/2"
Back, diameter	44"
Journals	8" x 14"
WHEEL BASE—Driving	13' 0"
Total engine	33' 0"
Total engine and tender	67' 2 1/4"
WEIGHT—On driving wheels	151,050 lbs.
On truck, front	51,700 lbs.
On truck, back	41,100 lbs.
Total engine	243,850 lbs.
Total engine and tender	402,700 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	8000 U. S. gals.
Fuel capacity	12 tons

SERVICE CONDITIONS—Rails, 85 pounds per yard.



Pacific Type Locomotive

for the

New York, New Haven and Hartford Railroad

Code Word—REFALSADO

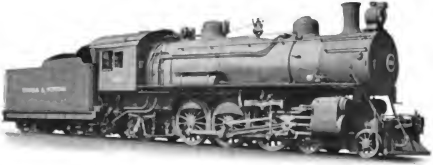
GENERAL DIMENSIONS

Baldwin Class 12-42-¼-D, 70
Railroad Company's Class I-3

Gauge 4' 8½"
Tractive Force, 34,800 lbs.

CYLINDERS	24" x 28"
Valves	Piston, 12" diam.
BOILER—Type	Straight top
Diameter	72"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	108⅛"
Width	71¼"
Depth, front	76"
Depth, back	68"
Tubes—Diameter	5½" and 2¼"
Number	5½", 28; 2¼", 180
Length	21' 6"
BOILER—*Continued*	
Heating Surface—Firebox	194 sq. ft.
Tubes	3132 sq. ft.
Firebrick tubes	29 sq. ft.
Total	3355 sq. ft.
Superheater	730 sq. ft.
Grate area	53.5 sq. ft.
DRIVING WHEELS—Diameter	79"
Journals	10" x 12"
TRUCK WHEELS—Front, diameter	36½"
Journals	6" x 12"
Back, diameter	51"
Journals	8" x 14"
WHEEL BASE—Driving	14' 1"
Total engine	35' 3½"
Total engine and tender	63' 4⅝"
WEIGHT—On driving wheels	153,100 lbs.
On truck, front	49,100 lbs.
On truck, back	44,000 lbs.
Total engine	246,200 lbs.
Total engine and tender	365,000 lbs.
TENDER—Wheels, diameter	36½"
Journals	5½" x 10"
Tank capacity	6000 U. S. gals.
Fuel capacity	13 tons

SERVICE CONDITIONS—Curves, 20 degrees.



Pacific Type Locomotive

for the

Norfolk and Western Railway

Code Word—REFASHION

Baldwin Class 12-38-¼-D, 478
Railway Company's Class E-2-A

Gauge 4' 8½"
Tractive Force, 34,400 lbs.

GENERAL DIMENSIONS

CYLINDERS	22½" x 28"
Valves	Piston, 12" diam.
BOILER—Type	Wagon top
Diameter	74"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	100¼"
Width	64¼"
Depth, front	78¼"
Depth, back	74½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 30; 2", 222
Length	20' 1"
BOILER—*Continued*	
Heating Surface—Firebox	192 sq. ft.
Tubes	3167 sq. ft.
Total	3359 sq. ft.
Superheater	756 sq. ft.
Grate area	44.7 sq. ft.
DRIVING WHEELS—Diameter	70"
Journals	10½" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	5½" x 10"
Back, diameter	42"
Journals	8" x 14"
WHEEL BASE—Driving	12' 6"
Total engine	32' 10½"
Total engine and tender	64' 9½"
WEIGHT—On driving wheels	163,850 lbs.
On truck, front	39,200 lbs.
On truck, back	46,200 lbs.
Total engine	249,250 lbs.
Total engine and tender	420,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	9000 U. S. gals.
Fuel capacity	14 tons

SERVICE CONDITIONS—Curves, 16 degrees.

Pacific Type Locomotive

for the

Chicago Great Western Railroad

Code Word—REFASTENED

GENERAL DIMENSIONS

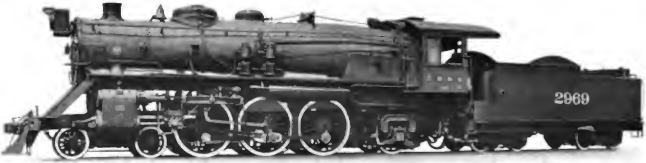
Baldwin Class 12-44-¼-D, 135
Railroad Company's Class K-5

Gauge 4' 8½"
Tractive Force, 38,700 lbs.

CYLINDERS	25" x 28"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	72"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length, total	126⅛"
Length of grate	96"
Width	84¼"
Depth, front	76"
Depth, back	64"
Tubes—Diameter	5½" and 2"
Number	5½", 32; 2", 239
Length	20' 6"

BOILER—*Continued*	
Heating Surface—Firebox	225 sq. ft.
Tubes	3474 sq. ft.
Firebrick tubes	33 sq. ft.
Total	3732 sq. ft.
Superheater	794 sq. ft.
Grate area	56 sq. ft.
DRIVING WHEELS—Diameter	73"
Journals, main	11" x 12"
Journals, others	9" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	6" x 10"
Back, diameter	52"
Journals	8" x 14"

WHEEL BASE—Driving	13' 0"
Total engine	35' 4"
Total engine and tender	66' 0"
WEIGHT—On driving wheels	152,400 lbs.
On truck, front	52,200 lbs.
On truck, back	52,400 lbs.
Total engine	257,000 lbs.
Total engine and tender	410,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	11 tons



Pacific Type Locomotive

for the

Chicago, Burlington and Quincy Railroad

Code Word—REFAUCHAIT

Baldwin Class 12-48-1/4-D, 78
Railroad Company's Class S-3

Gauge 4' 8 1/2"
Tractive Force, 42,200 lbs.

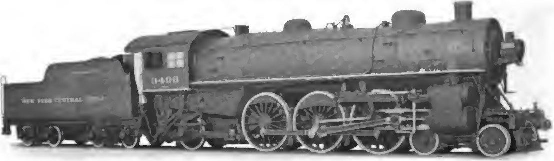
GENERAL DIMENSIONS

CYLINDERS	27" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	108 1/8"
Width	78 1/4"
Depth, front	85 1/4"
Depth, back	72"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 34; 2 1/4", 200
Length	18' 6"

BOILER—*Continued*	
Heating Surface—Firebox	233 sq. ft.
Combustion chamber	59 sq. ft.
Tubes	3072 sq. ft.
Total	3364 sq. ft.
Superheater	751 sq. ft.
Grate area	58.7 sq. ft.
DRIVING WHEELS—Diameter	74"
Journals, main	11" x 12"
Journals, others	10" x 12"
TRUCK WHEELS—Front, diameter	37 1/4"
Journals	6" x 12"
Back, diameter	48 1/4"
Journals	8" x 14"

WHEEL BASE—Driving	13' 0"
Total engine	33' 8 1/2"
Total engine and tender	68' 4"
WEIGHT—On driving wheels	171,300 lbs.
On truck, front	49,300 lbs.
On truck, back	48,600 lbs.
Total engine	269,200 lbs.
Total engine and tender	433,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5 1/2" x 10"
Tank capacity	8200 U. S. gals.
Fuel capacity	13 tons

SERVICE CONDITIONS—Curves, 21 degrees.



Pacific Type Locomotive

for the

New York Central Lines

Code Word—REFAUCHONS

Baldwin Class 12-40-¼-D, 23
Railroad Company's Class K-3-C

GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 30,900 lbs.

CYLINDERS	23½" x 26"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	72"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	108⅛"
Width	75¼"
Depth, front	82"
Depth, back	65"
Tubes—Diameter	5½" and 2¼"
Number	5½", 32; 2¼", 175
Length	21' 6"
BOILER—*Continued*	
Heating Surface—Firebox	204 sq. ft.
Tubes	3193 sq. ft.
Firebrick tubes	30 sq. ft.
Total	3427 sq. ft.
Superheater	803 sq. ft.
Grate area	56.5 sq. ft.
DRIVING WHEELS—Diameter	79"
Journals, main	10½" x 14"
Journals, others	10½" x 12"
TRUCK WHEELS—Front, diameter	36"
Journals	6½" x 12"
Back, diameter	50¼"
Journals	8" x 14"
WHEEL BASE—Driving	14' 0"
Total engine	36' 6"
Total engine and tender	67' 10"
WEIGHT—On driving wheels	171,300 lbs.
On truck, front	50,150 lbs.
On truck, back	47,900 lbs.
Total engine	269,350 lbs.
Total engine and tender	418,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	7500 U. S. gals.
Fuel capacity	12 tons

Pacific Type Locomotive

for the

Texas and Pacific Railway

Code Word—REFAZEDOR

Baldwin Class 12-46-¼-D, 176
Railway Company's Class P-1

Gauge 4' 8½"
Tractive Force, 40,900 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	74⅛"
Working pressure	185 lbs.
Fuel	Oil
Firebox—Length	114⅛"
Width	75⅛"
Depth, front	82"
Depth, back	67½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 34; 2", 242
Length	20' 6"
BOILER—*Continued*	
Heating Surface—Firebox	216 sq. ft.
Tubes	3564 sq. ft.
Total	3780 sq. ft.
Superheater	844 sq. ft.
Grate area	59.6 sq. ft.
DRIVING WHEELS—Diameter	73"
Journals, main	12" x 22"
Journals, others	10½" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	51"
Journals	9" x 14"
WHEEL BASE—Driving	13' 0"
Total engine	34' 7"
Total engine and tender	71' 5¼"
WEIGHT—On driving wheels	173,360 lbs.
On truck, front	48,140 lbs.
On truck, back	53,580 lbs.
Total engine	275,080 lbs.
Total engine and tender	450,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity, water	9000 U. S. gals.
Tank capacity, oil	3200 U. S. gals.
SERVICE CONDITIONS—Curves, 18 degrees.	

Pacific Type Locomotive

for the

Baltimore and Ohio Railroad

(United States Railroad Administration Standard Locomotive, Class 4-6-2-A)

Code Word—REFECTOIRE

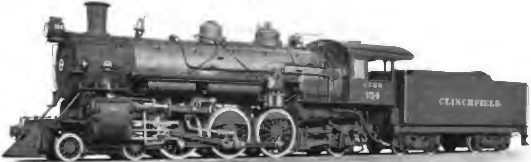
Baldwin Class 12-44-¼-D, 181
Railroad Company's Class P-5

Gauge 4' 8½"
Tractive Force, 40,700 lbs.

GENERAL DIMENSIONS

CYLINDERS	25" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Conical wagon top
Diameter	76"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	114⅛"
Width	84¼"
Depth, front	81½"
Depth, back	62½"
Tubes—Diameter	5½" and 2¼"
Number	5½", 36; 2¼", 188
Length	19' 0"
BOILER—*Continued*	
Heating Surface—Firebox	196 sq. ft.
Combustion chamber	46 sq. ft.
Tubes	3072 sq. ft.
Firebrick tubes	27 sq. ft.
Total	3341 sq. ft.
Superheater	794 sq. ft.
Grate area	66.7 sq. ft.
DRIVING WHEELS—Diameter	73"
Journals, main	11" x 13"
Journals, others	10" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	43"
Journals	9" x 14"
WHEEL BASE—Driving	13' 0"
Total engine	34' 11"
Total engine and tender	70' 7½"
WEIGHT—On driving wheels	167,100 lbs.
On truck, front	54,140 lbs.
On truck, back	54,530 lbs.
Total engine	275,770 lbs.
Total engine and tender	467,500 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Locomotive designed for 85-foot turntables, 19 degree curves and 2 per cent grades.



Pacific Type Locomotive

for the

Carolina, Clinchfield and Ohio Railway

Code Word—REFECTURAM

Baldwin Class 12-44-1/4-D, 142
Railway Company's Class P-2

Gauge 4' 8 1/2"
Tractive Force, 46,000 lbs.

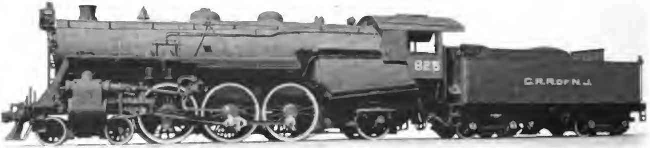
GENERAL DIMENSIONS

CYLINDERS	25" x 30"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	108 1/8"
Width	71 1/4"
Depth, front	81 1/2"
Depth, back	67 3/4"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 38; 2 1/4", 211
Length	21' 0"

BOILER—*Continued*	
Heating Surface—Firebox	208 sq. ft.
Tubes	3744 sq. ft.
Firebrick tubes	30 sq. ft.
Total	3982 sq. ft.
Superheater	955 sq. ft.
Grate area	53.8 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	11 1/2" x 13"
Journals, others	11" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6 1/2" x 12"
Back, diameter	45"
Journals	8" x 14"

WHEEL BASE—Driving	13' 0"
Total engine	34' 5"
Total engine and tender	66' 9 3/4"
WEIGHT—On driving wheels	176,900 lbs.
On truck, front	52,300 lbs.
On truck, back	51,100 lbs.
Total engine	280,300 lbs.
Total engine and tender	435,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5 1/2" x 10"
Tank capacity	9000 gals.
Fuel capacity	14 tons

SERVICE CONDITIONS—Curves, 16 degrees.



Pacific Type Locomotive

for the

Central Railroad of New Jersey

Code Word—REFEGADA

Baldwin Class 12-46-¼-D, 188

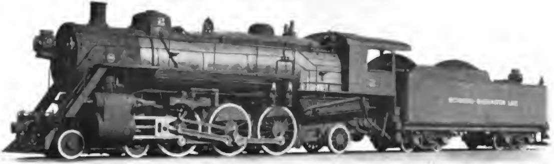
Gauge 4' 8½"

Tractive Force, 42,770 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	210 lbs.
Fuel	Fine anthracite
Firebox—Length	126⅛"
Width	108¼"
Depth, front	81¼"
Depth, back	60½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 252
Length	19' 0"
BOILER—*Continued*	
Heating Surface—Firebox	236 sq. ft.
Combustion chamber	67 sq. ft.
Tubes	3454 sq. ft.
Total	3757 sq. ft.
Superheater	816 sq. ft.
Grate area	94.8 sq. ft.
DRIVING WHEELS—Diameter	79"
Journals, main	11½" x 14"
Journals, others	10½" x 14"
TRUCK WHEELS—Front, diameter	36"
Journals	6½" x 12"
Back, diameter	48"
Journals	9" x 14"
WHEEL BASE—Driving	13' 10"
Total engine	35' 8"
Total engine and tender	72' 0¾"
WEIGHT—On driving wheels	181,400 lbs.
On truck, front	50,600 lbs.
On truck, back	59,400 lbs.
Total engine	291,400 lbs.
Total engine and tender	460,000 lbs
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	12 tons

SERVICE CONDITIONS—Curves, 12° 6'.



Pacific Type Locomotive

for the

Richmond, Fredericksburg and Potomac Railroad

Code Word—REFELLEBAT

Gauge 4' 8½"

Tractive Force, 47,300 lbs.

Baldwin Class 12-46-¼-D, 161

GENERAL DIMENSIONS

CYLINDERS	26" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	80"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	114⅛"
Width	84¼"
Depth, front	83"
Depth, back	67⅞"
Tubes—Diameter	5½" and 2¼"
Number	5½", 40; 2¼", 230
Length	20' 6"

BOILER—*Continued*

Heating Surface—Firebox	232 sq. ft.
Tubes	3942 sq. ft.
Firebrick tubes	31 sq. ft.
Total	4205 sq. ft.
Superheater	975 sq. ft.
Grate area	66.7 sq. ft.
DRIVING WHEELS—Diameter	68"
Journals	11½" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6" x 10"
Back, diameter	42"
Journals	8½" x 14"

WHEEL BASE—Driving	13' 0"
Total engine	34' 1"
Total engine and tender	72' 4"
WEIGHT (Estimated)—	
On driving wheels	188,000 lbs.
On truck, front	53,000 lbs.
On truck, back	52,000 lbs.
Total engine	293,000 lbs.
Total engine and tender	472,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	15 tons

SERVICE CONDITIONS—Turntables, 80 feet long; curves, 303 feet radius.

Pacific Type Locomotive

for the

St. Louis-San Francisco Railway

Code Word—REFELLERO

Baldwin Class 12-46-¼-D, 175

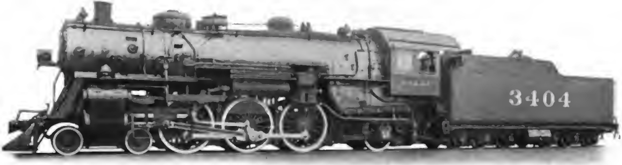
GENERAL DIMENSIONS

Gauge 4' 8½"

Tractive Force, 45,800 lbs.

CYLINDERS	26½" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Wagon top
Diameter	76½"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	115⅝"
Width	70"
Depth, front	90½"
Depth, back	74¾"
Tubes—Diameter	5½" and 2¼"
Number	5½", 38, 2¼", 225
Length	21' 0"
BOILER—*Continued*	
Heating Surface—Firebox	251 sq. ft.
Tubes	3916 sq. ft.
Firebrick tubes	33 sq. ft.
Total	4200 sq. ft.
Superheater	996 sq. ft.
Grate area	63.5 sq. ft.
DRIVING WHEELS—Diameter	73"
Journals, main	12" x 13½"
Journals, others	11" x 13½"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	42"
Journals	9½" x 14"
WHEEL BASE—Driving	13' 0"
Total engine	33' 11"
Total engine and tender	71' 7"
WEIGHT (Estimated)—	
On driving wheels	190,700 lbs.
On truck, front	45,300 lbs.
On truck, back	60,000 lbs.
Total engine	296,000 lbs.
Total engine and tender	487,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	18 tons

SERVICE CONDITIONS—Curves, 10 degrees. Locomotive designed to traverse curves of 16 degrees.



Pacific Type Locomotive

for the

Atchison, Topeka and Santa Fe Railway

Code Word—REFELLETIS

Baldwin Class 12-44-¼-D, 161
Railway Company's Class 3400

Gauge 4' 8½"
Tractive Force, 40,800 lbs.

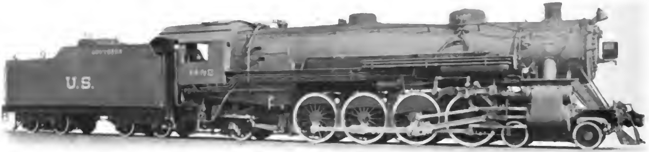
GENERAL DIMENSIONS

CYLINDERS	25" x 28"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	114"
Width	84¼"
Depth, front	84"
Depth, back	75"
Tubes—Diameter	5½" and 2¼"
Number	5½" 40; 2¼", 211
Length	21' 0"

BOILER—*Continued*	
Heating Surface—Firebox	235 sq. ft.
Tubes	3842 sq. ft.
Firebrick tubes	33 sq. ft.
Total	4110 sq. ft.
Superheater	942 sq. ft.
Grate area	66.5 sq. ft.
DRIVING WHEELS—Diameter	73"
Journals, main	11" x 13"
Journals, others	10½" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	7" x 12"
Back, diameter	50"
Journals	9" x 14"

WHEEL BASE—Driving	13' 8"
Total engine	35' 3"
Total engine and tender	71' 10⅞"
WEIGHT—On driving wheels	179,550 lbs.
On truck, front	60,600 lbs.
On truck, back	60,800 lbs.
Total engine	300,950 lbs.
Total engine and tender	534,670 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	12,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Curves, 16 degrees.



Mountain Type Locomotive

for the

Southern Railway

(United States Railroad Administration Standard Locomotive, Class 4-8-2-A)

Code Word—REFERAT

Baldwin Class 14-48-¼-E, 38

Gauge 4′ 8½″

Tractive Force, 53,900 lbs.

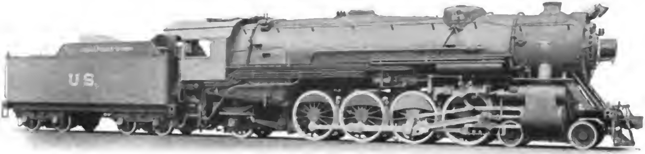
GENERAL DIMENSIONS

CYLINDERS	27″ x 30″
Valves	Piston, 14″ diam.
BOILER—Type	Conical wagon top
Diameter	78″
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	120⅛″
Width	84¼″
Depth, front	85″
Depth, back	64″
Tubes—Diameter	5½″ and 2¼″
Number	5½″, 40; 2¼″, 216
Length	20′ 6″

BOILER—*Continued*	
Heating Surface—Firebox	215 sq. ft.
Combustion chamber	105 sq. ft.
Tubes	3773 sq. ft.
Firebrick tubes	28 sq. ft.
Total	4121 sq. ft.
Superheater	957 sq. ft.
Grate area	70.8 sq. ft.
DRIVING WHEELS—Diameter	69″
Journals, main	12″ x 13″
Journals, others	10″ x 13″
TRUCK WHEELS—Front, diameter	33″
Journals	6½″ x 12″
Back, diameter	43″
Journals	9″ x 14″

WHEEL BASE—Driving	18′ 3″
Total engine	40′ 0″
Total engine and tender	75′ 8½″
WEIGHT—On driving wheels	224,500 lbs.
On truck, front	49,500 lbs.
On truck, back	53,000 lbs.
Total engine	327,000 lbs.
Total engine and tender	519,000 lbs.
TENDER—Wheels, diameter	36″
Journals	6″ x 11″
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Locomotive designed for 85-foot turntables, 19 degree curves and 2 per cent grades.



Mountain Type Locomotive

for the

Chesapeake and Ohio Railway

(United States Railroad Administration Standard Locomotive, Class 4-8-2-B)

Code Word—REFERCIES

Baldwin Class 14-50-¼-E, 14

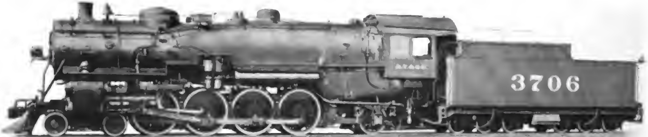
GENERAL DIMENSIONS

Gauge 4' 8½"

Tractive Force, 58,000 lbs.

CYLINDERS	28" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Conical wagon top
Diameter	86"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	114⅛"
Width	96¼"
Depth, front	91"
Depth, back	69½"
Tubes—Diameter	5½" and 2¼"
Number	5½", 45; 2¼", 247
Length	20' 6"
BOILER—*Continued*	
Heating Surface—Firebox	220 sq. ft.
Combustion chamber	115 sq. ft.
Tubes	4293 sq. ft.
Firebrick tubes	34 sq. ft.
Total	4662 sq. ft.
Superheater	1078 sq. ft.
Grate area	76.3 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	12" x 13"
Journals, others	11" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	43"
Journals	9" x 14"
WHEEL BASE—Driving	18' 3"
Total engine	40' 0"
Total engine and tender	75' 8½"
WEIGHT—On driving wheels	243,000 lbs.
On truck, front	51,500 lbs.
On truck, back	57,500 lbs.
Total engine	352,000 lbs.
Total engine and tender	546,000 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Locomotive designed for 85-foot turntables, 19 degree curves and 2 per cent grades.



Mountain Type Locomotive

for the

Atchison, Topeka and Santa Fe Railway

Code Word—REFERCIMUS

Baldwin Class 14-50-1/4-E, 7
Railway Company's Class 3700

Gauge 4' 8 1/2"
Tractive Force, 54,100 lbs.

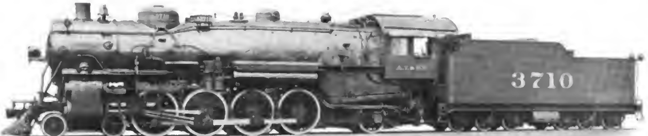
GENERAL DIMENSIONS

CYLINDERS	28" x 28"
Valves	Piston 15" diam.
BOILER—Type	Conical wagon top
Diameter	82"
Working pressure	200 lbs.
Fuel	Oil
Firebox—Length	122 1/4"
Width	84 1/4"
Depth, front	91 1/2"
Depth, back	77 3/4"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 43; 2 1/4", 254
Length	21' 0"

BOILER—*Continued*	
Heating Surface—Firebox	246 sq. ft.
Combustion chamber	90 sq. ft.
Tubes	4428 sq. ft.
Firebrick tubes	38 sq. ft.
Total	4802 sq. ft.
Superheater	1086 sq. ft.
Grate area	71.5 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	12" x 12"
Journals, others	11" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	7" x 12"
Back, diameter	45"
Journals	9" x 14"

WHEEL BASE—Driving	18' 0"
Total engine	39' 5"
Total engine and tender	76' 8 5/8"
WEIGHT (Reported by Railway Company)—	
On driving wheels	243,100 lbs.
On truck, front	58,100 lbs.
On truck, back	50,500 lbs.
Total engine	351,700 lbs.
Total engine and tender	594,100 lbs.
TENDER—Wheels, diameter	33"
Journals	5 1/2" x 10"
Tank capacity, water	12,000 U. S. gals.
Tank capacity, oil	4000 U. S. gals.

SERVICE CONDITIONS—Curves, 16 degrees.



Mountain Type Locomotive

for the

Atchison, Topeka and Santa Fe Railway

Code Word—REFERCIUNT

Baldwin Class 11-50-1/4-E, 11
Railway Company's Class 3700

Gauge 4' 8 1/2"
Tractive Force, 54,100 lbs.

GENERAL DIMENSIONS

CYLINDERS	28" x 28"
Valves	Piston, 15" diam.
BOILER—Type	Conical wagon top
Diameter	82"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	122 1/4"
Width	84 1/4"
Depth, front	91 1/2"
Depth, back	77 1/4"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 43; 2 1/4", 254
Length	21' 0"
BOILER—*Continued*	
Heating Surface—Firebox	246 sq. ft.
Combustion chamber	90 sq. ft.
Tubes	4428 sq. ft.
Firebrick tubes	38 sq. ft.
Total	4802 sq. ft.
Superheater	1086 sq. ft.
Grate area	71.5 sq. ft.
DRIVING WHEELS—Diameter	69"
Journals, main	12" x 12"
Journals, others	11" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	7" x 12"
Back, diameter	47"
Journals	9" x 14"
WHEEL BASE—Driving	18' 0"
Total engine	39' 3"
Total engine and tender	76' 8 5/8"
WEIGHT (Reported by Railway Company)—	
On driving wheels	243,100 lbs.
On truck, front	58,100 lbs.
On truck, back	66,500 lbs.
Total engine	367,700 lbs.
Total engine and tender	610,100 lbs.
TENDER—Wheels, diameter	31"
Journals	5 1/2" x 10"
Tank capacity	12,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Curves, 16 degrees.

General Offices of the Company

500 North Broad Street, Philadelphia

REPRESENTATIVES AND AGENTS

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St. Paul, Minn.	Henry Blanchard	908 Merchants National Bank Building
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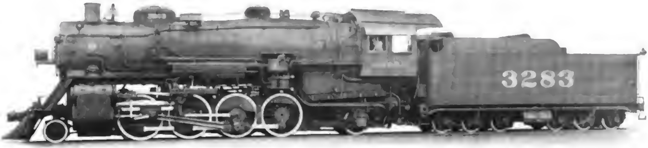
Scandinavia	Olav Belsheim	Christiania, Norway (Toldbogaden, 81)
Southern Africa	F. V. Green	Johannesburg
Spain	H. P. Austin	Madrid, Apartado 473
Victoria	Newell & Co.	Melbourne
Western Australia	Leslie & Co.	Perth
West Indies	G. R. Perez	Havana, 520 National [illegible] Cuba Bldg.



Mikado Type Locomotive

for the

Atchison, Topeka and Santa Fe Railway

Code Word—REFICHER

Baldwin Class 12-48-1/4-E, 1140
Railway Company's Class 3160

Gauge 4' 8 1/2"
Tractive Force, 59,800 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 32"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	82"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	114"
Width	84 1/4"
Depth, front	88 5/8"
Depth, back	78 5/8"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 43; 2 1/4", 252
Length	20' 9"
BOILER—*Continued*	
Heating Surface—Firebox	244 sq. ft.
Tubes	4348 sq. ft.
Firebrick tubes	34 sq. ft.
Total	4626 sq. ft.
Superheater	1086 sq. ft.
Grate area	66.8 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	12" x 12"
Journals, others	11" x 12"
TRUCK WHEELS—Front, diameter	30"
Journals	7" x 12"
Back, diameter	40"
Journals	9" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	35' 1"
Total engine and tender	71' 8 5/8"
WEIGHT—On driving wheels	240,270 lbs.
On truck, front	25,800 lbs.
On truck, back	56,850 lbs.
Total engine	322,920 lbs.
Total engine and tender	556,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5 1/2" x 10"
Tank capacity	12,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS— Curves, 16 degrees.

THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA.

Eight-Coupled Locomotives

for

Freight Service

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RECORD NO. 99

1920

CODE WORD—REFEREBAT

A Baldwin Mikado Type Locomotive in Service on the Virginian Railway.
East-bound from Roanoke, Va., the rating for these Locomotives is 100 loaded cars, averaging 7850 tons total weight. The maximum ascending grade is 0.2 per cent.

Eight-Coupled Freight Locomotives

THE greater part of the freight traffic on American railroads is moved by locomotives having four pairs of coupled driving wheels. The two types in most general use are the Consolidation (2-8-0) and the Mikado (2-8-2). Where track conditions permit heavy wheel-loads to be carried, either type can be designed to exert a maximum tractive force as high as 60,000 pounds.

The first Consolidation type locomotive for road service was built by The Baldwin Locomotive Works for the Lehigh Valley Railroad in 1866, to specifications prepared by Alexander Mitchell, Master Mechanic of that line. This locomotive was a marked success, and for many years thereafter, the Consolidation was the accepted type, in the United States, for the heaviest class of freight service. With the constant increase in the size of motive power, however, the limitations of the Consolidation type, as far as steaming capacity is concerned, became more and more apparent; and, in heavy service, these locomotives have been largely displaced by engines of the Mikado (2-8-2) type. The latter design was so named because it was first built for the Japan Railway. These locomotives were constructed by The Baldwin Locomotive Works in 1897. They were specially designed to burn a most inferior grade of fuel, and had large fireboxes which were placed back of the driving wheels and over the rear truck. They proved most satisfactory, and the type was subsequently adopted in the United States. The success of the Mikado type is largely due to its high steaming capacity, a most important feature in these days of heavy tonnage trains and difficult operating conditions.

Large locomotives of the Mikado type, and to a lesser extent of the Consolidation type, are frequently equipped with mechanical stokers; as when working at full capacity, they consume more coal than can be fired by hand. Superheaters are almost invariably applied to new locomotives of both these types; and all of the examples illustrated and described in the following pages, use superheated steam.

Consolidation Type Locomotive

for the

Coal and Coke Railway

Code Word—REFERENCIA

Baldwin Class 10-40-E, 175

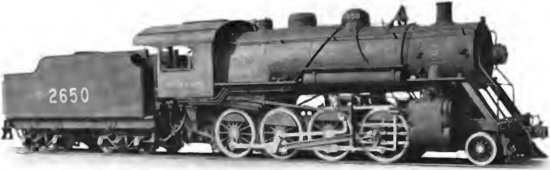
Gauge 4' 8½"

Tractive Force, 46,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 11" diam.
BOILER—Type	Wagon top
Diameter	72"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	105"
Width	71¼"
Depth, front	78"
Depth, back	64⅛"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 32; 2", 228
Length	13' 10"
BOILER—*Continued*	
Heating Surface—Firebox	184 sq. ft.
Tubes	2261 sq. ft.
Firebrick tubes	28 sq. ft.
Total	2473 sq. ft.
Superheater	526 sq. ft.
Grate area	52.3 sq. ft.
DRIVING WHEELS—Diameter	52"
Journals, main	10" x 13"
Journals, others	9" x 12"
TRUCK WHEELS—Diameter	30"
Journals	6" x 10"
WHEEL BASE—Driving	14' 3"
Total engine	23' 3"
Total engine and tender	55' 10"
WEIGHT—On driving wheels	176,000 lbs.
On truck	22,800 lbs.
Total engine	198,800 lbs.
Total engine and tender	330,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	7000 U. S. gals.
Fuel capacity	17 tons

SERVICE CONDITIONS—Grades, 85 feet per mile. Curves, 16 degrees on main line and 22 degrees on branch line.



Consolidation Type Locomotive

for the

Boston and Maine Railroad

Code Word—REFERENDAR

Baldwin Class 10-42-E, 255
Railroad Company's Class K-8

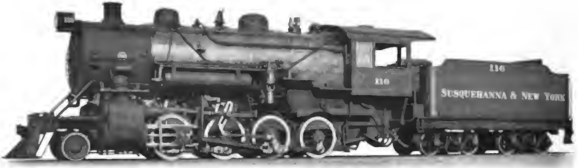
GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 43,380 lbs.

CYLINDERS	24" x 30"
Valves	Piston, 12" diam.
BOILER—Type	Wagon top
Diameter	70"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	108"
Width	71¼"
Depth, front	70½"
Depth, back	58"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 30; 2", 204
Length	14' 9"

BOILER—*Continued*	
Heating Surface—Firebox	178 sq. ft.
Tubes	2185 sq. ft.
Firebrick tubes	29 sq. ft.
Total	2392 sq. ft.
Superheater	522 sq. ft.
Grate area	53.4 sq. ft.
DRIVING WHEELS—Diameter	61"
Journals, main	10" x 12"
Journals, others	9½" x 12"
TRUCK WHEELS—Diameter	33"
Journals	6" x 12"

WHEEL BASE—Driving	17' 0"
Total engine	26' 0"
Total engine and tender	58' 2"
WEIGHT—On driving wheels	186,060 lbs.
On truck	24,940 lbs.
Total engine	211,000 lbs.
Total engine and tender	350,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	7300 U. S. gals.
Fuel capacity	12 tons



Consolidation Type Locomotive

for the

Susquehanna and New York Railroad

Code Word—REFERERAI

Baldwin Class 10-40-E, 176

Gauge 4' 8½"

Tractive Force, 45,500 lbs.

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Straight top
Diameter	80"
Working pressure	185 lbs.
Fuel	Soft coal
Firebox—Length	108"
Width	66"
Depth, front	75"
Depth, back	69½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 237
Length	14' 5"

BOILER—*Continued*	
Heating Surface—Firebox	193 sq. ft.
Tubes	2504 sq. ft.
Firebrick tubes	29 sq. ft.
Total	2726 sq. ft.
Superheater	626 sq. ft.
Grate area	49.5 sq. ft.
DRIVING WHEELS—Diameter	51"
Journals, main	10" x 12"
Journals, others	9" x 12"
TRUCK WHEELS—Diameter	30"
Journals	6" x 12"

WHEEL BASE—Driving	15' 8"
Total engine	24' 4"
Total engine and tender	55' 5½"
WEIGHT—On driving wheels	195,400 lbs.
On truck, front	17,500 lbs.
Total engine	212,900 lbs.
Total engine and tender	330,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5" x 9"
Tank capacity	6000 U. S. gals.
Fuel capacity	10 tons

Consolidation Type Locomotive

for the

Detroit and Toledo Shore Line Railroad

Code Word—REFERIAMOS

Baldwin Class 10-40-E, 170

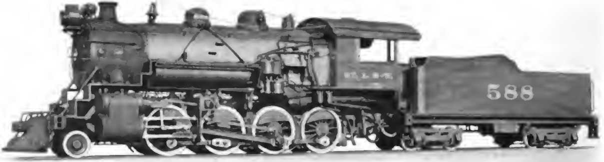
GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 38,500 lbs.

CYLINDERS	23" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	68⅜"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	96⅛"
Width	75¼"
Depth, front	72⅜"
Depth, back	56¼"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 26; 2", 207
Length	15' 0"

BOILER—*Continued*	
Heating Surface—Firebox	165 sq. ft.
Tubes	2162 sq. ft.
Firebrick tubes	28 sq. ft.
Total	2355 sq. ft.
Superheater	450 sq. ft.
Grate area	50.6 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	9½" x 12"
Journals, others	9" x 12"
TRUCK WHEELS—Diameter	31"
Journals	6½" x 12"

WHEEL BASE—Driving	17' 0"
Total engine	25' 9"
Total engine and tender	57' 3⅝"
WEIGHT—On driving wheels	190,600 lbs.
On truck	24,600 lbs.
Total engine	215,200 lbs.
Total engine and tender	370,000 lbs.
TENDER—Wheels, diameter	34"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	10 tons



Consolidation Type Locomotive

for the

St. Louis Southwestern Railway

Code Word—REFERIBLE

Baldwin Class 10-44-E, 268
Railway Company's Class K-1

Gauge 4' 8½"
Tractive Force, 49,600 lbs.

GENERAL DIMENSIONS

CYLINDERS	25" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Straight top
Diameter	80"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	108"
Width	70"
Depth, front	74⅜"
Depth, back	63⅜"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 32; 2", 245
Length	15' 0"

BOILER—*Continued*	
Heating Surface—Firebox	186 sq. ft.
Tubes	2585 sq. ft.
Firebrick tubes	29 sq. ft.
Total	2800 sq. ft.
Superheater	591 sq. ft.
Grate area	52.5 sq. ft.
DRIVING WHEELS—Diameter	61"
Journals, main	10½" x 13"
Journals, others	10" x 13"
TRUCK WHEELS—Diameter	30"
Journals	6" x 12"

WHEEL BASE—Driving	17' 6"
Total engine	26' 6"
Total engine and tender	62' 10¾"
WEIGHT—On driving wheels	202,300 lbs.
On truck	30,500 lbs.
Total engine	232,800 lbs.
Total engine and tender	410,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	15 tons

SERVICE CONDITIONS—Curves, 16 degrees.

Consolidation Type Locomotive

for the

Pennsylvania Lines

Code Word—REFERMAIT

Baldwin Class 10-46-E, 68
Railroad Company's Class H-10-S

Gauge 4' 8½"
Tractive Force, 53,140 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 28"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top Belpaire
Diameter	78½"
Working pressure	205 lbs.
Fuel	Soft coal
Firebox—Length	110¼"
Width	72"
Depth, front	72¾"
Depth, back	62"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 265
Length	15' 1"

BOILER—*Continued*	
Heating Surface—Firebox	175 sq. ft.
Tubes	2841 sq. ft.
Total	3016 sq. ft.
Superheater	623 sq. ft.
Grate area	55 sq. ft.
DRIVING WHEELS—Diameter	62"
Journals	10½" x 13"
TRUCK WHEELS—Diameter	33"
Journals	5½" x 10"

WHEEL BASE—Driving	17' 0½"
Total engine	25' 9½"
Total engine and tender	62' 5⅛"
WEIGHT—On driving wheels	226,900 lbs.
On truck	22,600 lbs.
Total engine	249,500 lbs.
Total engine and tender	431,000 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	8000 U. S. gals
Fuel capacity	34,600 lbs.

Consolidation Type Locomotive

for the

Union Railroad

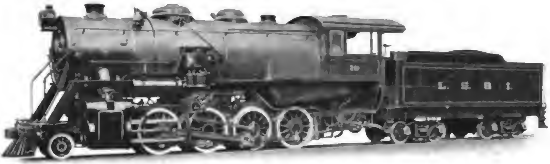
Code Word—REFERMASSE

Baldwin Class 10-44-E, 321

Gauge 4' $8\frac{1}{2}$"
Tractive Force, 58,700 lbs.

GENERAL DIMENSIONS

CYLINDERS	25" x 32"
Valves	Piston, 12" diam.
BOILER—Type	Straight top
Diameter	84"
Working pressure	190 lbs
Fuel	Soft coal
Firebox—Length	$111\frac{1}{2}$"
Width	$70\frac{1}{4}$"
Depth, front	$79\frac{1}{2}$"
Depth, back	70"
Tubes—Diameter	$5\frac{1}{2}$" and $2\frac{1}{4}$"
Number	$5\frac{1}{2}$", 36; $2\frac{1}{4}$", 200
Length	15' 0"
BOILER—*Continued*	
Heating Surface—Firebox	214 sq. ft
Tubes	2530 sq. ft.
Firebrick tubes	27 sq. ft.
Total	2771 sq. ft.
Superheater	654 sq. ft
Grate area	54.4 sq. ft.
DRIVING WHEELS—Diameter	55"
Journals, main	11" x 13"
Journals, others	$9\frac{1}{2}$" x 13"
TRUCK WHEELS—Diameter	30"
Journals	6" x 12"
WHEEL BASE—Driving	16' 4"
Total engine	25' 1"
Total engine and tender	60' $1\frac{1}{2}$"
WEIGHT—On driving wheels	240,320 lbs
On truck	19,940 lbs.
Total engine	260,260 lbs
Total engine and tender	404,000 lbs
TENDER—Wheels, diameter	33"
Journals	$5\frac{1}{2}$" x 10"
Tank capacity	8000 U. S. gals
Fuel capacity	12 tons



Consolidation Type Locomotive

for the

Lake Superior and Ishpeming Railway

Code Word—REFERMIEZ

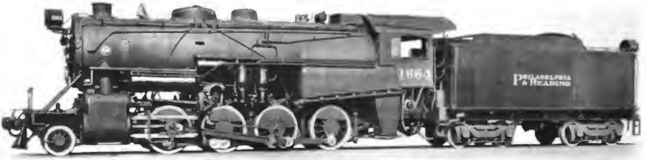
Baldwin Class 10-46-E, 93

Gauge 4' 8 1/2"
Tractive Force, 55,900 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Straight top
Diameter	88"
Working pressure	185 lbs.
Fuel	Soft coal
Firebox—Length	108 1/8"
Width	78 1/4"
Depth, front	84"
Depth, back	66 1/2"
Tubes—Diameter	5 3/8" and 2"
Number	5 3/8", 45; 2", 300
Length	15' 6"
BOILER—*Continued*	
Heating Surface—Firebox	216 sq. ft.
Tubes	3398 sq. ft.
Firebrick tubes	29 sq. ft.
Total	3643 sq. ft.
Superheater	844 sq. ft.
Grate area	58.7 sq. ft.
DRIVING WHEELS—Diameter	57"
Journals	11" x 13"
TRUCK WHEELS—Diameter	30"
Journals	6 1/2" x 12"
WHEEL BASE—Driving	16' 0"
Total engine	26' 0"
Total engine and tender	60' 11 1/2"
WEIGHT (Estimated)—	
On driving wheels	238,000 lbs.
On truck	30,000 lbs.
Total engine	268,000 lbs.
Total engine and tender	425,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	8500 U. S. gals.
Fuel capacity	13 tons

SERVICE CONDITIONS—Curves, 5 degrees. Grades, 1.63 per cent.



Consolidation Type Locomotive

for the

Philadelphia and Reading Railway

Code Word—REFERMIONS

Baldwin Class 10-44-E, 284
Railway Company's Class I-9-SA

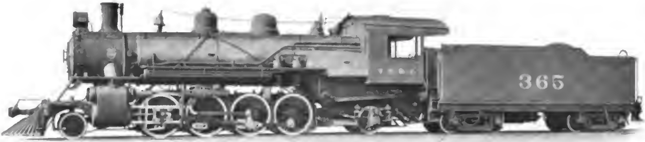
GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 61,260 lbs.

CYLINDERS	25" x 32"
Valves	Piston, 13" diam.
BOILER—Type	Conical wagon top
Diameter	79¼"
Working pressure	200 lbs
Fuel	Hard and soft coal mixed
Firebox—Length	126⅛"
Width	108⅛"
Depth, front	78½"
Depth, back	56½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 239
Length	13' 6"

BOILER—*Continued*	
Heating Surface—Firebox	225 sq. ft.
Combustion chamber	71 sq. ft.
Tubes	2359 sq. ft.
Total	2655 sq. ft.
Superheater	575 sq. ft.
Grate area	94.9 sq. ft.
DRIVING WHEELS—Diameter	55½"
Journals	11" x 13"
TRUCK WHEELS—Diameter	33"
Journals	7" x 11"

WHEEL BASE—Driving	17' 0"
Total engine	27' 0"
Total engine and tender	63' 11"
WEIGHT—On driving wheels	250,800 lbs.
On truck	30,300 lbs.
Total engine	281,100 lbs.
Total engine and tender	462,000 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	9500 U. S. gals.
Fuel capacity	15 tons



Mikado Type Locomotive

for the

Vicksburg, Shreveport and Pacific Railway

Code Word—REFERSISTI

Baldwin Class 12-38-¼-E, 149

Gauge 4' 8½"
Tractive Force, 40,400 lbs.

GENERAL DIMENSIONS

CYLINDERS	22" x 28"
Valves	Piston, 13" diam.
BOILER—Type	Straight top
Diameter	66"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length, total	110⅝"
Length of grate	87"
Width	76"
Depth, front	67½"
Depth, back	57"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 24; 2", 172
Length	19' 3"
BOILER—*Continued*	
Heating Surface—Firebox	171 sq. ft.
Tubes	2373 sq. ft.
Firebrick tubes	29 sq. ft.
Total	2573 sq. ft.
Superheater	546 sq. ft.
Grate area	46 sq. ft.
DRIVING WHEELS—Diameter	57"
Journals, main	9½" x 11"
Journals, others	9" x 11"
TRUCK WHEELS—Front, diameter	33"
Journals	5½" x 10"
Back, diameter	40"
Journals	7½" x 12"
WHEEL BASE—Driving	15' 0"
Total engine	33' 6"
Total engine and tender	68' 2¾"
WEIGHT—On driving wheels	168,400 lbs.
On truck, front	19,500 lbs.
On truck, back	29,600 lbs.
Total engine	217,500 lbs.
Total engine and tender	367,500 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	7500 U. S. gals.
Fuel capacity	14 tons

Mikado Type Locomotive

for the

Missouri, Oklahoma and Gulf Railway

Code Word—REFERTERO

Baldwin Class 12-40-1/4-E, 10
Railway Company's Class MK-52-[illegible]-44

Gauge 4' 8 1/2"
Tractive Force, 43,600 lbs.

GENERAL DIMENSIONS

CYLINDERS	23" x 28"
Valves	Piston, 11" diam.
BOILER—Type	Straight top
Diameter	82"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	114 1/8"
Width	72 1/4"
Depth, front	81 1/2"
Depth, back	67 1/2"
Tubes—Diameter	5 3/8" and 2"
Number	5 3/8", 38; 2", 265
Length	18' 6"
BOILER—*Continued*	
Heating Surface—Firebox	208 sq. ft.
Tubes	3540 sq. ft.
Firebrick tubes	30 sq. ft.
Total	3778 sq. ft.
Superheater	838 sq. ft.
Grate area	57.2 sq. ft.
DRIVING WHEELS—Diameter	52"
Journals, main	10" x 12"
Journals, others	9 1/2" x 12"
TRUCK WHEELS—Front, diameter	30"
Journals	5" x 10"
Back, diameter	36"
Journals	7 1/2" x 10"
WHEEL BASE—Driving	14' 3"
Total engine	32' 4"
Total engine and tender	65' 7 1/2"
WEIGHT—On driving wheels	177,100 lbs.
On truck, front	20,900 lbs.
On truck, back	34,000 lbs.
Total engine	232,000 lbs.
Total engine and tender	386,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5 1/2" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	13 tons

Mikado Type Locomotive

for the

Nashville, Chattanooga and St. Louis Railway

Code Word—REFERTORUM

Baldwin Class 12-44-¼-E, 113
Railway Company's Class L-1

Gauge 4' 8½"
Tractive Force, 49,500 lbs.

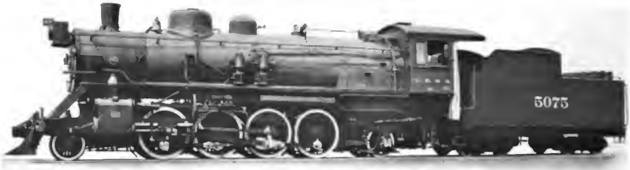
GENERAL DIMENSIONS

CYLINDERS	25" x 30"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	76"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	114⅛"
Width	84¼"
Depth, front	85¼"
Depth, back	72½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 34; 2", 241
Length	20' 6"

BOILER—*Continued*	
Heating Surface—Firebox	224 sq. ft.
Tubes	3553 sq. ft.
Firebrick tubes	27 sq. ft.
Total	3804 sq. ft.
Superheater	840 sq. ft.
Grate area	66.6 sq. ft.
DRIVING WHEELS—Diameter	58"
Journals, main	11" x 21"
Journals, others	9½" x 12"
TRUCK WHEELS—Front, diameter	31"
Journals	5½" x 12"
Back, diameter	36"
Journals	8" x 14"

WHEEL BASE—Driving	15' 9"
Total engine	34' 4"
Total engine and tender	69' 7⅛"
WEIGHT—On driving wheels	215,800 lbs.
On truck, front	22,500 lbs.
On truck, back	34,400 lbs.
Total engine	272,700 lbs.
Total engine and tender	438,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8500 U. S. gals.
Fuel capacity	14 tons

SERVICE CONDITIONS—Curves, 339 feet radius.



Mikado Type Locomotive

for the

Chicago, Burlington and Quincy Railroad

Code Word—REFERTOS

Baldwin Class 12-48-1/4-E, 1010
Railroad Company's Class O-1 A

Gauge 4' 8 1/2"
Tractive Force, 52,200 lbs.

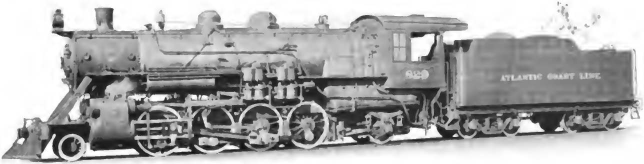
GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	108 1/8"
Width	78 1/4"
Depth, front	85 3/8"
Depth, back	72"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 34; 2 1/4", 200
Length	18' 6"

BOILER—*Continued*	
Heating Surface—Firebox	233 sq. ft.
Combustion chamber	59 sq. ft.
Tubes	3072 sq. ft.
Total	3364 sq. ft.
Superheater	751 sq. ft.
Grate area	58.7 sq. ft.
DRIVING WHEELS—Diameter	64"
Journals, main	11" x 12"
Journals, others	10" x 12"
TRUCK WHEELS—Front, diameter	37 1/4"
Journals	6" x 10"
Back, diameter	42 1/2"
Journals	8" x 14"

WHEEL BASE—Driving	16' 9"
Total	33' 9 1/2"
Total engine and tender	68' 5"
WEIGHT—On driving wheels	211,300 lbs.
On truck, front	27,900 lbs.
On truck, back	39,400 lbs.
Total engine	278,600 lbs.
Total engine and tender	472,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	19 tons

SERVICE CONDITIONS— Curves, 20 degrees.



Mikado Type Locomotive

for the

Atlantic Coast Line Railroad

Code Word—REFERVEBIT

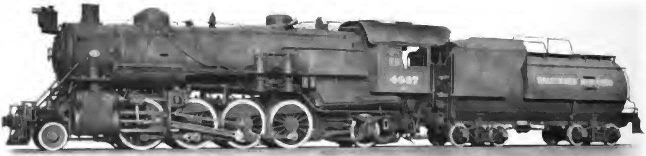
Baldwin Class 12-48-¼-E, 949
Railroad Company's Class M-2

Gauge 4' 8½"
Tractive Force, 59,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 12" diam.
BOILER—Type	Conical wagon top
Diameter	78"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	120⅛"
Width	88"
Depth, front	85"
Depth, back	76½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 240
Length	16' 6"
BOILER—*Continued*	
Heating Surface—Firebox	231 sq. ft.
Combustion chamber	86 sq. ft.
Tubes	2954 sq. ft.
Firebrick tubes	35 sq. ft.
Total	3306 sq. ft.
Superheater	742 sq. ft.
Grate area	73.4 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	12" x 15"
Journals, others	9½" x 12"
TRUCK WHEELS—Front, diameter	31½"
Journals	6" x 10"
Back, diameter	44"
Journals	8" x 14"
WHEEL BASE—Driving	16' 9"
Total engine	35' 0"
Total engine and tender	69' 2½"
WEIGHT—On driving wheels	223,200 lbs.
On truck, front	18,000 lbs.
On truck, back	39,500 lbs.
Total engine	280,700 lbs.
Total engine and tender	475,000 lbs.
TENDER—Wheels, diameter	36"
Journals	6" x 11"
Tank capacity	9500 U. S. gals.
Fuel capacity	12 tons

SERVICE CONDITIONS—Rails, 85 lbs. per yard.



Mikado Type Locomotive

for the

Baltimore and Ohio Railroad

Code Word—REFERVER

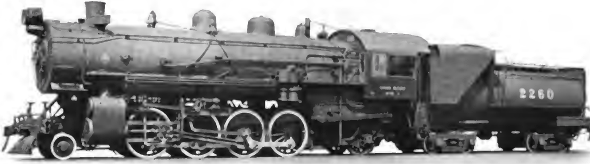
Baldwin Class 12-46-1/4-E, 317
Railroad Company's Class Q-7-f

Gauge 4' 8 1/2"
Tractive Force, 54,600 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 32"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	78"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	120"
Width	84"
Depth, front	81"
Depth, back	71 1/2"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 34; 2 1/4", 218
Length	21' 0"
BOILER—*Continued*	
Heating Surface—Firebox	228 sq. ft.
Tubes	3710 sq. ft.
Firebrick tubes	32 sq. ft.
Total	3970 sq. ft.
Superheater	882 sq. ft.
Grate area	70 sq. ft.
DRIVING WHEELS—Diameter	64"
Journals, main	11 1/2" x 21"
Journals, others	9 1/2" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6" x 10"
Back, diameter	46"
Journals	8" x 14"
WHEEL BASE—Driving	16' 9"
Total engine	35' 0"
Total engine and tender	72' 0"
WEIGHT—On driving wheels	222,100 lbs.
On truck, front	18,800 lbs.
On truck, back	41,000 lbs.
Total engine	281,900 lbs.
Total engine and tender	463,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Curves, 22 degrees.



Mikado Type Locomotive

for the

Union Pacific System

Code Word—REFERVIDA

Baldwin Class 12-46-1/4-E, 360
Railroad Company's Class MK-63-[illegible]-219-S

Gauge 4' 8 1/2"
Tractive Force, 51,100 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 28"
Valves	Piston, 15" diam.
BOILER—Type	Straight top
Diameter	82"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	120 1/8"
Width	84"
Depth, front	87 1/2"
Depth, back	73 1/2"
Tubes—Diameter	5 3/8" and 2"
Number	5 3/8", 36; 2", 275
Length	20' 6"
BOILER—*Continued*	
Heating Surface—Firebox	242 sq. ft.
Tubes	3974 sq. ft.
Total	4216 sq. ft.
Superheater	912 sq. ft.
Grate area	70 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	11" x 12"
Journals, others	9" x 12"
TRUCK WHEELS—Front, diameter	30"
Journals	6 1/2" x 14"
Back, diameter	45"
Journals	8" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	35' 2"
Total engine and tender	69' 9 1/8"
WEIGHT—On driving wheels	219,400 lbs.
On truck, front	24,500 lbs.
On truck, back	38,900 lbs.
Total engine	282,800 lbs.
Total engine and tender	450,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	14 tons

Mikado Type Locomotive

for the

Chicago Great Western Railroad

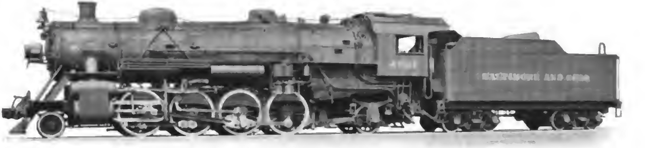
Code Word—REFESTELLA

Baldwin Class 12-48-¼-E, 729
Railroad Company's Class L-1-S

Gauge 4' 8½"
Tractive Force, 55,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 15" diam.
BOILER—Type	Straight top
Diameter	82"
Working pressure	182 lbs.
Fuel	Soft coal
Firebox—Length, total	161"
Length of grate	116"
Width	84"
Depth, front	79½"
Depth, back	74½"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36, 2", 262
Length	18' 6"
BOILER—*Continued*	
Heating Surface—Firebox	260 sq. ft.
Tubes	3459 sq. ft.
Firebrick tubes	40 sq. ft.
Total	3759 sq. ft.
Superheater	798 sq. ft.
Grate area	67.7 sq. ft
DRIVING WHEELS—Diameter	63"
Journals, main	11" x 15"
Journals, others	9" x 12"
TRUCK WHEELS—Front, diameter	33"
Journals	6" x 10"
Back, diameter	42¼"
Journals	8" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	36' 1"
Total engine and tender	66' 3½"
WEIGHT—On driving wheels	221,500 lbs.
On truck, front	23,800 lbs.
On truck, back	40,600 lbs.
Total engine	285,900 lbs.
Total engine and tender	440,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10'
Tank capacity	8000 U. S. gals.
Fuel capacity	15 tons



Mikado Type Locomotive

for the

Baltimore and Ohio Railroad

(United States Railroad Administration Standard Locomotive, Class 2-8-2-A)

Code Word—REFESTINES

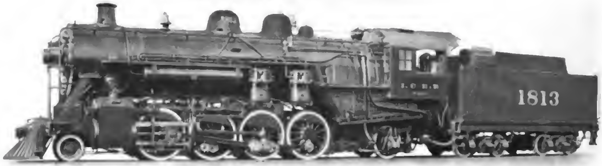
Baldwin Class 12-46-¼-E, 442
Railroad Company's Class Q-3

Gauge 4' 8½"
Tractive Force, 54,600 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Conical wagon top
Diameter	78"
Working pressure	200 lbs.
Fuel	Soft coal
Firebox—Length	114¼"
Width	84¼"
Depth, front	82½"
Depth, back	61½"
Tubes—Diameter	5½" and 2¼"
Number	5½", 40; 2¼", 216
Length	19' 0"
BOILER—*Continued*	
Heating Surface—Firebox	203 sq. ft.
Combustion chamber	50 sq. ft.
Tubes	3497 sq. ft.
Firebrick tubes	27 sq. ft.
Total	3777 sq. ft.
Superheater	945 sq. ft.
Grate area	66.7 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	11" x 13"
Journals, others	10" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	43"
Journals	9" x 14"
WHEEL BASE—Driving	16' 9"
Total engine	36' 1"
Total engine and tender	71' 4½"
WEIGHT—On driving wheels	221,500 lbs.
On truck, front	20,200 lbs.
On truck, back	49,100 lbs.
Total engine	290,800 lbs.
Total engine and tender	474,700 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Locomotive designed for 85-foot turntables, 19 degree curves and 2 per cent grades.



Mikado Type Locomotive

for the

Illinois Central Railroad

Code Word—REFESTINO

Baldwin Class 12-48-¼ E, 911
Railroad Company's Class MK-63-32-51.7

Gauge 4' 8½"
Tractive Force, 51,630 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 15" diam.
BOILER—Type	Straight top
Diameter	82"
Working pressure	175 lbs.
Fuel	Soft coal
Firebox—Length	120⅛"
Width	84"
Depth, front	87½"
Depth, back	74"
Tubes—Diameter	5⅜" and 2"
Number	5⅜", 36; 2", 262
Length	20' 6"
BOILER—*Continued*	
Heating Surface—Firebox	240 sq. ft.
Tubes	3834 sq. ft.
Firebrick tubes	32 sq. ft.
Total	4106 sq. ft.
Superheater	887 sq. ft.
Grate area	70.4 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals	11" x 12"
TRUCK WHEELS—Front, diameter	30½"
Journals	6" x 10"
Back, diameter	45"
Journals	8" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	35' 2"
Total engine and tender	65' 10"
WEIGHT—On driving wheels	226,800 lbs.
On truck, front	23,900 lbs.
On truck, back	43,200 lbs.
Total engine	293,900 lbs.
Total engine and tender	462,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals
Fuel capacity	15 tons

Mikado Type Locomotive

for the

Virginian Railway

Code Word—REFETTORIO

Baldwin Class 12-46-¼-E, 21
Railway Company's Class MC

Gauge 4' 8½"
Tractive Force, 60,500 lbs.

GENERAL DIMENSIONS

CYLINDERS	26" x 32"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	86"
Working pressure	185 lbs.
Fuel	Soft coal
Firebox—Length	114"
Width	72"
Depth, front	91"
Depth, back	79½"
Tubes—Diameter	5½" and 2¼"
Number	5½", 40; 2¼", 230
Length	19' 0"
BOILER—*Continued*	
Heating Surface—Firebox	233 sq. ft.
Tubes	4096 sq. ft.
Firebrick tubes	30 sq. ft.
Total	4359 sq. ft.
Superheater	910 sq. ft.
Grate area	57 sq. ft.
DRIVING WHEELS—Diameter	56"
Journals	11" x 13"
TRUCK WHEELS—Front, diameter	30"
Journals	6" x 12"
Back, diameter	37"
Journals	8" x 14"
WHEEL BASE—Driving	15' 0"
Total engine	33' 3"
Total engine and tender	71' 2¾"
WEIGHT—On driving wheels	229,600 lbs.
On truck, front	23,600 lbs.
On truck, back	44,300 lbs.
Total engine	297,500 lbs.
Total engine and tender	500,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	12,000 U. S. gals.
Fuel capacity	15 tons

SERVICE CONDITIONS—Curves, 20 degrees.

Mikado Type Locomotive

for the

Great Northern Railway

Code Word—REFFKAMM

Baldwin Class 12-50-¼-E, 333
Railway Company's Class O-1

GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 60,930 lbs.

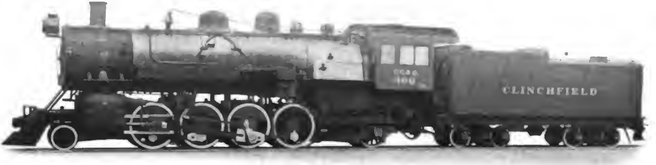
CYLINDERS	28" x 32"
Valves	Piston, 13" diam.
BOILER—Type	Wagon top Belpaire
Diameter	82"
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	117"
Width	96"
Depth, front	83¾"
Depth, back	75¾"
Tubes—Diameter	5½" and 2"
Number	5½", 36; 2", 304
Length	21' 0"

BOILER—*Continued*

Heating Surface—Firebox	252 sq. ft.
Tubes	4413 sq. ft.
Total	4665 sq. ft.
Superheater	918 sq. ft.
Grate area	78 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	11" x 16"
Journals, others	10" x 12"
TRUCK WHEELS—Front, diameter	33½"
Journals	6" x 11½"
Back, diameter	42½"
Journals	8" x 14"

WHEEL BASE—Driving	16' 9"
Total engine	35' 0"
Total engine and tender	68' 1"
WEIGHT—On driving wheels	229,000 lbs.
On truck, front	25,400 lbs.
On truck, back	52,100 lbs.
Total engine	306,500 lbs.
Total engine and tender	460,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	13 tons

SERVICE CONDITIONS—Curves, 10 degrees.



Mikado Type Locomotive

for the

Carolina, Clinchfield and Ohio Railway

Code Word—REFIBULABO

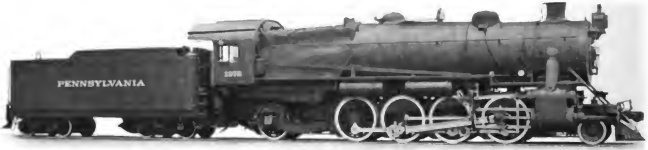
Baldwin Class 12-48-¼-E, 937
Railway Company's Class K-1

GENERAL DIMENSIONS

Gauge 4' 8½"
Tractive Force, 56,000 lbs.

CYLINDERS	27" x 30"
Valves	Piston, 15" diam.
BOILER—Type	Straight top
Diameter	82"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	116⅛"
Width	96"
Depth, front	89"
Depth, back	73½"
Tubes—Diameter	5½" and 2¼"
Number	5½", 42; 2¼", 209
Length	21' 0"
BOILER—*Continued*	
Heating Surface—Firebox	248 sq. ft.
Tubes	3836 sq. ft.
Firebrick tubes	33 sq. ft.
Total	4117 sq. ft.
Superheater	933 sq. ft.
Grate area	78 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	11½" x 13"
Journals, others	11" x 13"
TRUCK WHEELS,—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	45"
Journals	8" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	36' 0"
Total engine and tender	69' 1½"
WEIGHT—On driving wheels	230,000 lbs.
On truck, front	28,400 lbs.
On truck, back	53,000 lbs.
Total engine	311,400 lbs.
Total engine and tender	500,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	15 tons

SERVICE CONDITIONS—Curves, 16 degrees.



Mikado Type Locomotive

for the

Pennsylvania Railroad

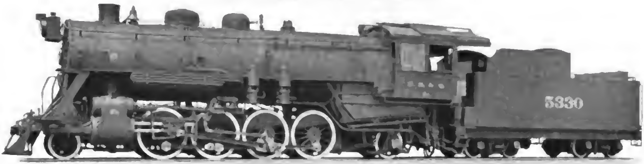
Code Word—REFIBULES

Baldwin Class 12-48-¼-E, 951
Railroad Company's Class L-1-S

Gauge 4' 8½"
Tractive Force, 61,500 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 12" diam.
BOILER—Type	Wagon top Belpaire
Diameter	78¼"
Working pressure	205 lbs.
Fuel	Soft coal
Firebox—Length	126"
Width	80"
Depth, front	89¼"
Depth, back	67¼"
Tubes—Diameter	5½" and 2¼"
Number	5½", 40; 2¼", 236
Length	19' 1"
BOILER—*Continued*	
Heating Surface—Firebox	226 sq. ft.
Combustion chamber	62 sq. ft.
Tubes	3735 sq. ft.
Firebrick tubes	35 sq. ft.
Total	4058 sq. ft.
Superheater	962 sq. ft.
Grate area	70 sq. ft.
DRIVING WHEELS—Diameter	62"
Journals	11" x 15"
TRUCK WHEELS—Front, diameter	33"
Journals	6½" x 12"
Back, diameter	50"
Journals	6½" x 12"
WHEEL BASE—Driving	17' 0½"
Total engine	36' 4½"
Total engine and tender	73' 4½"
WEIGHT—On driving wheels	237,500 lbs.
On truck, front	27,700 lbs.
On truck, back	49,400 lbs.
Total engine	314,600 lbs.
Total engine and tender	496,000 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	9000 U. S. gals.
Fuel capacity	35,000 lbs.



Mikado Type Locomotive

for the

Chicago, Burlington and Quincy Railroad

Code Word—REFIBULO

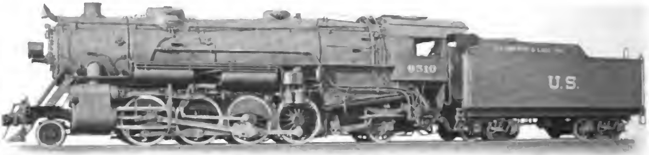
Baldwin Class 12-50-¼-E, 356
Railroad Company's Class O-3

Gauge 4′ 8½″
Tractive Force, 60,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	28″ x 32″
Valves	Piston, 14″ diam.
BOILER—Type	Straight top
Diameter	88½″
Working pressure	180 lbs.
Fuel	Soft coal
Firebox—Length	116⅞″
Width	96″
Depth, front	91½″
Depth, back	76¼″
Tubes—Diameter	5½″ and 2¼″
Number	5½″, 45; 2¼″, 264
Length	18′ 7¼″
BOILER—*Continued*	
Heating Surface—Firebox	277 sq. ft.
Combustion chamber	69 sq. ft.
Tubes	4080 sq. ft.
Firebrick tubes	39 sq. ft.
Total	4465 sq. ft.
Superheater	1031 sq. ft.
Grate area	78 sq. ft.
DRIVING WHEELS—Diameter	64″
Journals, main	11″ x 12″
Journals, others	10″ x 12″
TRUCK WHEELS—Front, diameter	37¼″
Journals	6″ x 10″
Back, diameter	42½″
Journals	8″ x 14″
WHEEL BASE—Driving	16′ 9″
Total engine	35′ 9″
Total engine and tender	69′ 11½″
WEIGHT—On driving wheels	239,200 lbs.
On truck, front	27,600 lbs
On truck, back	47,900 lbs.
Total engine	314,700 lbs.
Total engine and tender	508,400 lbs.
TENDER—Wheels, diameter	33″
Journals	6″ x 11″
Tank capacity	10,000 U. S. gals.
Fuel capacity	20 tons

SERVICE CONDITIONS—Curves, 20 degrees.



Mikado Type Locomotive

for the

Pittsburgh & Lake Erie Railroad

(United States Railroad Administration Standard Locomotive, Class 2-8-2-B)

Code Word—REFICERENT

Baldwin Class 12-48-1/4-E, 1075

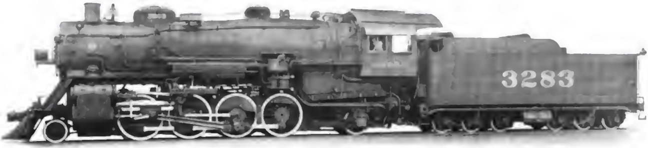
Gauge 4' 8 1/2"

Tractive Force, 60,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 32"
Valves	Piston, 14" diam.
BOILER—Type	Conical wagon top
Diameter	86"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	120 1/8"
Width	84 1/4"
Depth, front	90 5/8"
Depth, back	68 5/8"
Tubes—Diameter	5 1/2" and 2 1/4"
Number	5 1/2", 45; 2 1/4", 247
Length	19' 0"
BOILER—*Continued*	
Heating Surface—Firebox	228 sq. ft.
Combustion chamber	51 sq. ft.
Tubes	3978 sq. ft.
Firebrick tubes	28 sq. ft.
Total	4285 sq. ft.
Superheater	993 sq. ft.
Grate area	70.3 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	12" x 13"
Journals, others	10" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	6 1/2" x 12"
Back, diameter	43"
Journals	9" x 14"
WHEEL BASE—Driving	16' 9"
Total engine	36' 1"
Total engine and tender	71' 8 1/2"
WEIGHT—On driving wheels	239,000 lbs.
On truck, front	24,000 lbs.
On truck, back	57,000 lbs.
Total engine	320,000 lbs.
Total engine and tender	503,800 lbs.
TENDER—Wheels, diameter	33"
Journals	6" x 11"
Tank capacity	10,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Locomotive designed for 85-foot turntables, 19 degree curves and 2 per cent grades.



Mikado Type Locomotive

for the

Atchison, Topeka and Santa Fe Railway

Code Word—REFICHER

Baldwin Class 12-48-¼-E, 1140
Railway Company's Class 3160

Gauge 4' 8½"
Tractive Force, 59,800 lbs.

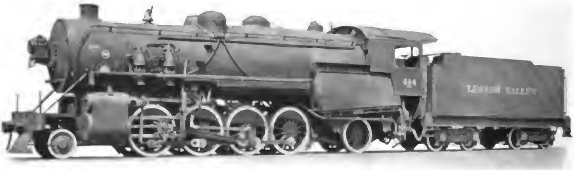
GENERAL DIMENSIONS

CYLINDERS	27" x 32"
Valves	Piston, 15" diam.
BOILER—Type	Wagon top
Diameter	82"
Working pressure	190 lbs.
Fuel	Soft coal
Firebox—Length	114"
Width	84¼"
Depth, front	88⅝"
Depth, back	78⅜"
Tubes—Diameter	5½" and 2¼"
Number	5½", 43; 2¼", 252
Length	20' 9"

BOILER—*Continued*	
Heating Surface—Firebox	244 sq. ft.
Tubes	4348 sq. ft.
Firebrick tubes	34 sq. ft.
Total	4626 sq. ft.
Superheater	1086 sq. ft.
Grate area	66.8 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals, main	12" x 12"
Journals, others	11" x 12"
TRUCK WHEELS—Front, diameter	30"
Journals	7" x 12"
Back, diameter	40"
Journals	9" x 14"

WHEEL BASE—Driving	16' 6"
Total engine	35' 1"
Total engine and tender	71' 8⅝"
WEIGHT—On driving wheels	240,270 lbs.
On truck, front	25,800 lbs.
On truck, back	56,850 lbs.
Total engine	322,920 lbs.
Total engine and tender	556,000 lbs.
TENDER—Wheels, diameter	33"
Journals	5½" x 10"
Tank capacity	12,000 U. S. gals.
Fuel capacity	16 tons

SERVICE CONDITIONS—Curves, 16 degrees.



Mikado Type Locomotive

for the

Lehigh Valley Railroad

Code Word—REFIGEBAR

Baldwin Class 12-48-¼-E, 752
Railroad Company's Class N-3

Gauge 4' 8½"
Tractive Force, 57,000 lbs.

GENERAL DIMENSIONS

CYLINDERS	27" x 30"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	83¾"
Working pressure	190 lbs.
Fuel	Hard and soft coal mixed
Firebox—Length	125¾"
Width	114⅛"
Depth, front	88⅝"
Depth, back	74¼"
Tubes—Diameter	5½" and 2¼"
Number	5½", 45; 2¼", 254
Length	17' 6"
BOILER—*Continued*	
Heating Surface—Firebox	260 sq. ft.
Combustion chamber	88 sq. ft.
Tubes	3734 sq. ft.
Firebrick tubes	59 sq. ft.
Total	4150 sq. ft.
Superheater	980 sq. ft.
Grate area	100 sq. ft.
DRIVING WHEELS—Diameter	63"
Journals	11" x 14"
TRUCK WHEELS—Front, diameter	33"
Journals	7" x 12"
Back, diameter	50"
Journals	9" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	35' 2"
Total engine and tender	67' 11½"
WEIGHT—On driving wheels	232,000 lbs.
On truck, front	39,000 lbs.
On truck, back	54,200 lbs.
Total engine	325,200 lbs.
Total engine and tender	480,000 lbs
TENDER—Wheels, diameter	36"
Journals	5½" x 10"
Tank capacity	8000 U. S. gals.
Fuel capacity	25,000 lbs.

Mikado Type Locomotive

for the

Philadelphia and Reading Railway

Code Word—REFIGERIS

Baldwin Class 12-42-¼-E, 399
Railway Company's Class M-1

Gauge 4' 8½"
Tractive Force, 57,320 lbs.

GENERAL DIMENSIONS

CYLINDERS	24" x 32"
Valves	Piston, 14" diam.
BOILER—Type	Wagon top
Diameter	84"
Working pressure	225 lbs.
Fuel	Hard and soft coal mixed
Firebox—Length	144¼"
Width	108¼"
Depth, front	80"
Depth, back	59¼"
Tubes—Diameter	5½" and 2¼"
Number	5½", 48; 2¼", 239
Length	17' 8"
BOILER—*Continued*	
Heating Surface—Firebox	245 sq. ft.
Combustion chamber	81 sq. ft.
Tubes	3898 sq. ft.
Total	4224 sq. ft.
Superheater	993 sq. ft.
Grate area	108 sq. ft.
DRIVING WHEELS—Diameter	61½"
Journals	11" x 13"
TRUCK WHEELS—Front, diameter	33"
Journals	7" x 11"
Back, diameter	42¼"
Journals	8" x 14"
WHEEL BASE—Driving	16' 6"
Total engine	35' 0"
Total engine and tender	68' 5½"
WEIGHT—On driving wheels	246,600 lbs.
On truck, front	26,800 lbs.
On truck, back	55,900 lbs.
Total engine	329,300 lbs.
Total engine and tender	485,000 lbs.
TENDER—Wheels, diameter	36"
Journals	5½" x 10½"
Tank capacity	8000 U. S. gals.
Fuel capacity	12.8 tons

General Offices of the Company

500 North Broad Street, Philadelphia

REPRESENTATIVES AND AGENTS

New York, N. Y.	Richard Sanderson	120 Broadway
Chicago, Ill.	Charles Riddell	627 Railway Exchange
St. Louis, Mo.	A. S. Goble	1210 Boatmen's Bank Building
Richmond, Va.	G. F. Jones	712-713 Mutual Building
Pittsburgh, Pa.	E. Converse Peirce	279 Union Arcade Building
Houston, Texas	Paul G. Cheatham	1501 Carter Building
St. Paul, Minn.	Henry Blanchard	908 Merchants National Bank Building
San Francisco, Cal.	Williams, Dimond & Co.	310 Sansome Street
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New Zealand	Phillips & Pike	Wellington
Peru	C. R. Cullen	Lima
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Portuguese East Africa	Vines & Co., Ltd.	Lourenço Marques, Delagoa Bay
Scandinavia	Olav Belsheim	Christiania, Norway (Toldbogaden, 8)
Southern Africa	F. V. Green	Johannesburg
Spain	H. P. Austin	Madrid, Apartado 473
Victoria	Newell & Co.	Melbourne
Western Australia	Leslie & Co.	Perth
West Indies	G. R. Perez	Havana, 520 National Bank of Cuba Bldg.

THE BALDWIN LOCOMOTIVE WORKS

RECORD No. 100

WALSCHAERTS VALVE GEAR

If the main rod, crosshead and piston on the damaged side are in a condition to run, the main rod may be left up, provided there are relief valves in the cylinder heads. The relief valves should be removed, so that the cylinder can be lubricated and excessive compression avoided. With the eccentric rod down, and the valve securely blocked in its middle position, the engine can then be run with the other side. It is of course necessary, in this case, to remove the crosshead link, and fasten the combining lever in forward position. The foot of the lever can readily be secured to one of the cylinder cocks.

If the damage is confined to the eccentric crank or rod, or to the lower end of the link, and the latter is still supported on its trunnions, the main rod may be left up, and the valve operated by the combining lever. To accomplish this, take down the eccentric rod, disconnect the radius rod from the reverse shaft, and secure the link-block exactly at the center of the link. The maximum port opening on the damaged side will now be equal to the lead, and the cut-off will be very short; but the steam will do at least some work, and the engine can be reversed and both the cylinders lubricated.

Reproducing Model of the Walschaerts Valve Gear

Figure 30 shows a full size model used by The Baldwin Locomotive Works for reproducing the motion of the Walschaerts valve gear, applied to locomotives. On this model can be measured all the valve events, such as travel, lead, cut-off, release, etc., in both forward and backward motions; and any relative position of the valve to the piston can be found. This machine has adjustable parts which may be made to conform to the length of the actual parts on the locomotive, and arranged in the same relative location.

To obtain the motion the machine is driven at the wheel by an electric motor, or revolved by hand to suit the operator.

The valve events may be permanently recorded on

SANTA FE TYPE LOCOMOTIVE WITH WALSCHAERTS VALVE GEAR
CHICAGO, BURLINGTON AND QUINCY RAILROAD

Walschaerts Valve Gear

SINCE the year 1905, the Walschaerts valve gear has come into extensive use in American locomotive practice, and it is now more generally employed, especially on heavy power for road service, than any other form of motion. The principal advantage of this gear lies in the accessibility of its parts, which are placed entirely outside the driving wheels. This facilitates oiling, inspection and cleaning; operations which are frequently difficult to carry out in locomotives equipped with the Stephenson link motion. Furthermore, in heavy engines equipped with the Stephenson gear, the eccentrics must be made of large diameter to secure the required throw. This increases the velocity of the rubbing surfaces and also the tendency to heat, especially in the case of locomotives which have comparatively small wheels and are employed in high speed service. In the Walschaerts gear the various parts are pin-connected, and are easily lubricated; hence troubles due to heating are reduced to a minimum.

The Walschaerts motion is of the radial type, and it employs a link which is trunnioned at its middle point. The link is rocked by means of an eccentric rod, whose motion is usually derived from a return crank, secured to the main crank pin. The movement of the link is transmitted to the valve stem by a radius rod, whose length is equal to the link radius. This radius rod is pinned to the sliding link block, and can be raised or lowered by the reverse lever. When the block is above the link center, the engine runs in one direction, and when below the center, in the opposite direction; the direction of movement being determined by conditions to be subsequently explained.

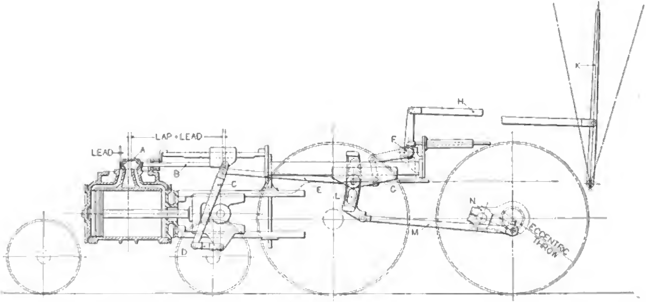


FIG. 1

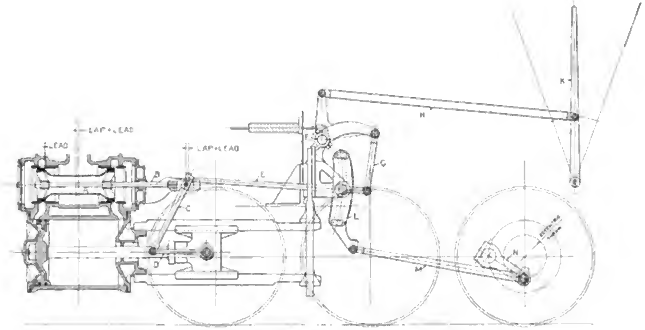


FIG. 2

The return crank on the main pin (known as the eccentric crank) is so set that, when the piston is at the extreme end of its stroke, the link stands in its middle position; and it is evident that if the radius rod were attached directly to the valve stem, the valve would also be in its middle position. When, however, the piston is at the end of its stroke, the valve should be displaced from its middle position by an amount equal to the steam lap plus the lead. In the Walschaerts gear the valve is given lead by a combining lever, which is attached to both the valve stem and the radius rod, and is also connected, through a suitable link, to the crosshead. This combining lever is so proportioned that if the point of its connection to the radius rod be kept a stationary fulcrum, and the piston moved a distance equal to the stroke, the valve will be moved a distance equal to twice the lap plus the lead. Therefore when the piston is at the end of its stroke, the valve is displaced from its middle position a distance equal to the lap plus the lead, and the correct steam distribution is secured.

The accompanying diagrams show two arrangements of Walschaerts motion. Figure 1 represents a design used with outside admission slide valves, and Figure 2 a design used with inside admission piston valves. In both cases corresponding parts are similarly designated by letters, as follows:

A—valve
B—valve stem
C—combining lever
D—crosshead link
E—radius rod
F—reverse shaft
G—lifting link
H—reach rod
K—reverse lever
L—reverse link
M—eccentric rod
N—eccentric crank

The main pin is shown on the forward dead center, and the reverse lever is in its middle position, with the

link block in the center of the link. A careful study of the diagrams reveals the following facts:

With a valve having *outside admission*—

The valve rod is connected to the combining lever at a point *above* the latter's connection to the radius rod.

If the block is in the *lower* half of the link when in forward gear, the eccentric crank *leads* the main pin.

If the block is in the *upper* half of the link when in forward gear, the eccentric crank *follows* the main pin.

With a valve having *inside admission*—

The valve rod is connected to the combining lever at a point *below* the latter's connection to the radius rod.

If the block is in the *lower* half of the link when in forward gear, the eccentric crank *follows* the main pin.

If the block is in the *upper* half of the link when in forward gear, the eccentric crank *leads* the main pin.

The two diagrams, Figures 1 and 2, show the arrangement of the valve gear as generally used, but the motion may be designed in various ways in order to adapt it to the construction of the locomotive to which it is applied. The principal variations are found in the method of supporting and controlling the link radius rod, and modern design usually comprises a combination of the following:—

The rod supported in *front* of or *back* of the link.

The rod supported by a *swinging bar* or *sliding block*.

The reverse shaft located in *front* of or *back* of the link.

As it is always desirable to have the reverse lever forward in forward motion, the arrangement of the reverse shaft will generally determine whether the block should be in the top or bottom part of the link in forward motion, and the eccentric crank must be set accordingly.

Inasmuch as the position of the valve, when the piston is at the end of its stroke, is dependent on the combining lever only, it is evident that the lead given by the Walschaerts gear is the same for all points of cut-off. This is the principal feature which distinguishes this gear from the Stephenson motion as far as steam distribution is concerned. All parts of the Walschaerts motion should be correctly laid out and constructed from

a diagram, and the gear designed to give the lead most desirable for the usual running speed. The parts having been correctly made, it is impossible to alter the lead without seriously deranging the motion. In this respect the Walschaerts gear is less flexible than the Stephenson; but when the correct steam distribution is obtained it is less liable to derangement, and the engine is more easily kept "square."

The accompanying illustrations represent seven arrangements of this gear, as applied to recent locomotives of various types. The styles shown are briefly described as follows:

FIG. 3

Figure 3 shows the gear as applied to an American type locomotive, with slide valves. The link bearings are bolted to the guide yoke, and the reverse shaft bearings to a cross-brace placed immediately ahead of the main driving wheels.

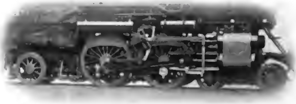


FIG. 4

Figure 4 shows the gear as used on an Atlantic type locomotive. A cast steel bearer, placed between the two pairs of driving wheels, supports the link and reverse shaft bearings. The valve is of the piston type, with inside admission; and as the radius rod is down in forward gear, the eccentric crank follows the main pin.

FIG. 5

Figure 5 shows an arrangement of motion as applied to a ten-wheeled locomotive with slide valves. The links are carried on longitudinal bearers, placed outside the leading pair of driving wheels.

FIG. 6

Figure 6 shows an arrangement used on a Pacific type locomotive with inside admission piston valves. The valve rod is here supported by guides which are cast on an extension of the back steam-chest head.

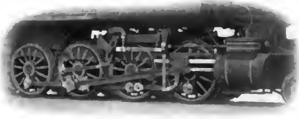


FIG. 7

Figure 7 shows a design of motion used when the steam chest center is inside the cylinder center. A rocker transmits the movement from the plane of the gear to the center of the steam chest. This is a satisfactory arrangement to apply when the cylinders are interchangeable with those of locomotives using the Stephenson link motion.

FIG. 8

Figure 8 shows the gear as applied to a Mikado type locomotive with Ragonnet Type B power reverse mechanism.

Figure 9 shows a design of motion used on a large Mallet articulated locomotive with Ragonnet Type A power reverse gear. The valves of the rear engine are arranged for inside admission, and those of the front engine for outside admission. The front and back reverse shafts are connected by a jointed reach rod, and the gears of the two engines are simultaneously controlled by the same reverse mechanism.

All the gears illustrated are so arranged that the main guides can be lined up without disturbing the adjustment of the motion work.

The gears shown are typical of recent practice, but they by no means represent all the modifications in successful use. The general design of the engine influences, to a large extent, the arrangement of the motion.

Mention has been made of the fact that all parts of the Walschaerts gear must be laid down on a diagram in order to insure a correct steam distribution. If all the details could be made and assembled exactly to the drawings, the operation of "valve setting" would be unnecessary. In practice, however, such accuracy cannot be obtained; and after the gear has been assembled some adjustment is usually required.

Method of Setting Valves with Walschaerts Gear

The object of valve setting is to so adjust the valve gear that the opening and closing of the ports will occur at proper intervals, and upon this depends the efficiency

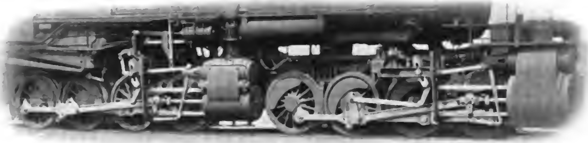


FIG. 9

and smooth running of the locomotive. While the same practice is not always followed in setting the valves, it is the general custom to set them with the lead constant at both ports for all positions of the reverse lever; and unless the cut-off points at the position of the lever where the engine is most frequently operated show considerable difference, the valve setting may be considered sufficiently correct.

Assuming that all detail parts have been checked with their respective drawings and that the main rod is up and the gear fully connected, the procedure is as follows:

Obtaining Exact Dead Centers. Block the main driving boxes, allowing one-half inch over the central position for settling, viz.: add one-half inch to the dimension between the top of the frame and the center line of the driving journal, as given on the erecting diagram.

Place the main crank approximately six or eight inches below the forward dead center. Put a prick

punch mark O on any convenient place on the crosshead gib, and scribe with a tram or a pair of dividers the line A-A on the guide. Then prick punch the point A′ at any convenient place on the line A-A (see Figure 10).

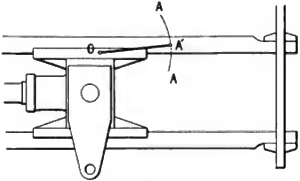


FIG. 10

Next prick punch the engine frame at any convenient place ahead of the driving wheel, and with a long tram scribe the line B-B on the tire. Prick punch the point B′ at a definite position (say one inch from edge of tire) on this line (see Figure 11).

Now revolve the wheel backward until the main crank comes above the forward dead center, stopping it when the tram used in Figure 10 reaches exactly

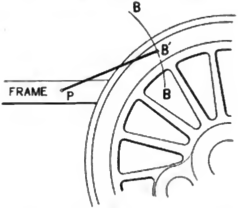


FIG. 11

from the point O on the crosshead to the point A′ on the guide (see Figure 10).

Then re-tram the frame to the tire as in Figure 12, using the same tram and the same point P as in Figure 11.

Scribe the line C-C and punch the point C′ at exactly the same distance from the edge of the tire as previously used in locating B′. This operation will place the point B′ (previously obtained) at a distance Q from point C′. Now prick punch the point D at a position exactly central between C′ and B′ and at the same distance from the edge of the tire that was used in their location (one inch was previously suggested).

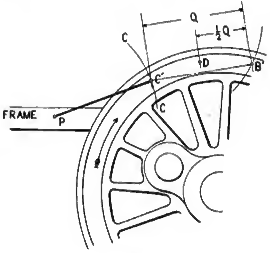


FIG. 12

Now if the wheel be revolved forward until the long tram reaches exactly from point P to point D, the main crank will be on the exact forward dead center.

Proceed in like manner to obtain the exact backward dead center, reversing the operation and using the same points on the crosshead and frame, and a new point (forward of the crosshead) on the guide.

The standard method used by The Baldwin Locomotive Works for marking these centers is shown on Figure 13. The trial points are indicated by a single punch mark only, while the final points are indicated by three punch marks, the outermost ones being the actual tram points (D and D′).

The points S and S′, as shown on Figure 13, are indicated in a similar manner; the outermost punch marks representing the actual tram points used for marking the half stroke positions.

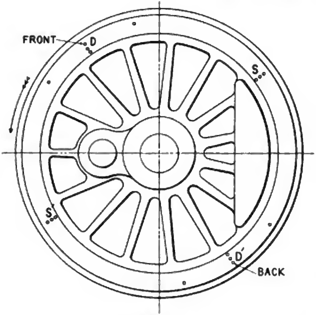


FIG. 13

To obtain the points S and S', set the crosshead on the forward dead center and measure back on the guides one-half the piston stroke, as shown on Figure 14.

Then revolve the wheel forward until the crosshead moves from position X to position Y. Now with the long tram obtain point S by tramming from point P on

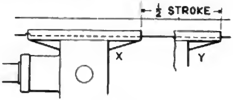


FIG. 14

the frame (Figures 11 and 12), prick punching point S at the same distance from the edge of the tire as point D.

The opposite half stroke point S' may be obtained by the same method, preferably revolving the wheel in the same direction (arrow on Figure 13) so that the influence of lost motion in the parts may be minimized.

The four important points on the stroke are now definitely established on the wheel, and are ready to be used for valve setting.

Note: If desired, any other positions of the stroke can be marked on the wheel by using the long tram and the method of procedure described above.

Setting of Outside Admission Slide Valves

1. With the ports exposed, place the valve with its steam edge just cutting off the ports (at each end successively), and prick punch the valve stem at points

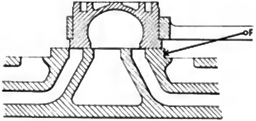


FIG. 15

F and F', obtained by tramming from any convenient place on the valve seat or shelf (see Figures 15 and 16). The distance between points F and F' will be equal to twice the lap of the valve. When the valve is leading (main crank on either dead center) the port should be open by an amount equal to the desired lead (see Figure 17).

If the tram is used with the valve on its lead, then the distance between the points so found and the point F

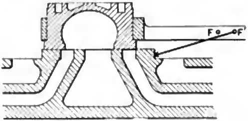


FIG. 16

on the valve stem will be equal to the lead (see dimension V on Figure 17).

With this statement in mind, proceed as follows:

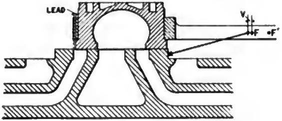


FIG. 17

2. Hook up the gear so that the link block is exactly central with the link. Place the main crank on the forward dead center, and tram to the valve stem.

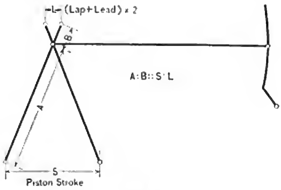


FIG. 18

Revolve the wheel to the backward dead center, and again tram to the valve stem. Measure the distance between the points so obtained, and compare the same with the specification. The distance should be equal to twice the sum of the lap and lead. Variation from the specified figures means that an error exists in the combining lever, the upper and lower arms of which are made respectively proportional in length to twice the lap and lead and to the stroke of the piston. (See Figure 18).

Assuming that the distance L, as trammed on the valve stem, is found correct, the procedure is now as follows:

3. Place the gear in forward motion, with the link block at a point in the link that will give the specified maximum valve travel when the wheels are revolved in a forward direction (this position of the link block is obtained by experiment).

4. Place the main crank on the forward dead center, by tramming from P to D; and with the same tram as used for marking the valve stem (Figures 15 and 16) scribe on the stem, measuring the distance between the point so obtained and the punch mark F. This distance should be exactly equal to the specified lead.

5. Revolve the wheel in a forward direction until the main crank is on the back dead center (tram from P to D′), and similarly scribe on the valve stem, measuring the distance between the point so obtained and the punch mark F′. This distance should also be exactly equal to the specified lead.

6. Place the gear in backward motion (as instruction No. 3) and examine for lead at the front and back exactly as described in instructions 4 and 5, except that the wheel must be revolved in a backward direction.

If all the points so found are exactly to specification, the valve setting is square. A check should now be made by placing the piston on the forward dead center, and moving the link block through its entire travel in the link. This should in no way disturb the position of the valve.

7. The gear should now be tried for the maximum valve travel, setting the reverse lever to give the greatest movement to the valve (with the proper clearance of the link block at the end of the link), and measuring the travel so obtained. The cut-off points may now be measured on the piston stroke, after which it is advisable to place the piston at the cut-off points at which the engine is most frequently worked. If this is unknown, very satisfactory results may be secured by assuming it to be 50% of the stroke on freight, and 30% on passenger locomotives.

In marking the forward and backward gear positions on a reverse quadrant of a "cold engine" an allowance toward the front of the quadrant must be made on each end, to correct for expansion when the engine is under steam. The amount of such allowance is a matter of judgment, but one-quarter to three-eighths of an inch can be considered sufficient for ordinary standard gauge engines.

Corrections

If, on trial, the valve gear is found to be out of square on the lead points, the following hypothetical cases will serve to explain the corrections that should be made.

For example, suppose the specification calls for the following:

Maximum valve travel, $5\frac{1}{2}''$

Eccentric crank throw, $11''$

Constant lead, $\frac{1}{4}''$

Outside lap of valve, $1''$

Link block below link center in forward gear.

It is very important that the following dimensions check exactly with the drawings:

1. Length of combining lever between central fulcrum and upper and lower arm centers (see Figure 18, dimensions B and A).

2. Eccentric crank throw and length of crank arm.

In the case under consideration the prick punch marks on the valve stem (refer to Figures 15, 16) will be two inches from center to center (this is twice the valve lap).

3. A change in the length of the eccentric rod results in a change in the position of the valve, approximately in proportion to the eccentric throw and valve travel. In the present case, this is as eleven to five and one-half or as two to one. In other words, a change of one-quarter inch in the length of the eccentric rod will move the valve approximately one-eighth inch when the link block is in full gear and the main crank is on the dead center.

4. The influence of eccentric rod changes on the direction (ahead or back) of the movement of the valve is explained by reference to Figure 19. An examination of Figure 19 will show that if the eccentric rod E is lengthened to E′, then the radius rod R will be moved ahead to the position R′, and the valve stem will be moved a distance X in the direction of the arrow, thus displacing the valve from position V to position V′.

5. The following rules can thus be formulated:

If the link block is below the link center when running ahead, then—

In forward motion,

If the eccentric rod is lengthened, the valve is moved ahead.

If the eccentric rod is shortened, the valve is moved back.

In backward motion,

If the eccentric rod is lengthened, the valve is moved back.

If the eccentric rod is shortened, the valve is moved ahead.

If the link block is above the center when running ahead, then, in each case, the valve will be moved in the direction opposite to that stated above.

6. Corrections made to the link radius rod will have approximately full influence on the movement of the valve, viz.: any variation in the radius rod will produce approximately the same variation in the movement of the valve.

7. The link fulcrum Z (see Figure 19) is a fixed point; therefore, the direction of movement due to changes in the radius rod will vary directly with such changes, and the following rules can be formulated:

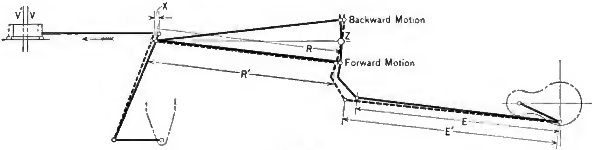


FIG. 19

In either forward motion or backward motion,

To move the valve ahead, lengthen the radius rod the amount desired.

To move the valve back, shorten the radius rod the amount desired.

This is true whether the link block is above or below the link center in forward gear.

8. With these facts in mind, two hypothetical cases will be considered.

Hypothetical Case No. 1

Let it be assumed that, on tramming to the valve stem with the main crank on the dead centers, the following irregularities in the lead are noticed for the engine under consideration. The dots on the diagrams represent the prick punch marks F and F′ (see Figure 16) on the valve stem, while the crosses represent the irregularities in the lead when trammed to the valve stem (see Figure 20).

9. The first procedure will be to divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, $3/8'' - 1/4''$ lead $= 1/8''$ error
Back, $1/4''$ lead $- 1/8'' = 1/8''$ error

To square the lead, the valve must be moved $1/8''$ ahead.

Error in backward motion—

Front, $7/16'' - 1/4''$ lead $= 3/16''$ error
Back, $1/4''$ lead $- 1/16'' = 3/16''$ error

To square the lead, the valve must be moved $3/16''$ ahead.

As the errors in the two motions occur in the same direction, it follows that the greater one partially neu-

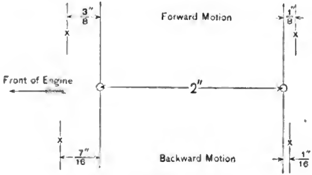


FIG. 20

tralizes the effect of the lesser, and that the combined or average error will be the difference between the two, viz.: three-sixteenths of an inch minus one-eighth inch equals one-sixteenth inch average error.

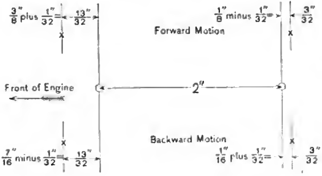


FIG. 21

10. To divide an average error of one-sixteenth inch equally about a central point, it will be necessary to move the valve one-half this amount, or one-thirty-second inch (in this case one-thirty-second inch back in forward motion).

According to rule 3, the eccentric rod must be shortened one-sixteenth inch (in the proportion of two to one) to move the valve one-thirty-second inch. When this has been done the valve stem points will tram as shown in Figure 21.

11. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is five-thirty-seconds of an inch too far back to equalize the lead, viz.:

$^{13}/_{32}{}'' - {}^{1}/_{4}{}''$ lead $= {}^{5}/_{32}{}''$ error front.

$^{1}/_{4}{}''$ lead $- {}^{3}/_{32}{}'' = {}^{5}/_{32}{}''$ error back.

12. As the influence of the radius rod is direct (see rules 6 and 7) it follows that by lengthening this rod the amount required (five-thirty-seconds of an inch) the valve will be squared, and can be trammed to the dimensions shown by Figure 22. These dimensions are the ones required by the specification.

13. The valve has thus been squared and the errors corrected in Hypothetical Case No. 1, by the changes noted below:

Eccentric rod shortened $^1/_{16}''$

Link radius rod lengthened $^5/_{32}''$

14. A final trial of the valve and cut-off, etc., can now be made in the previously described manner.

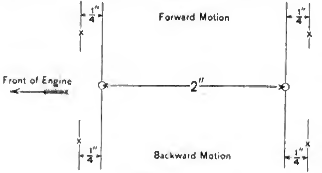


FIG. 22

Hypothetical Case No. 2

Let it be assumed that on tramming for lead, results are obtained as represented by Figure 23.

15. Divide the error between the forward and backward motions as follows:

Error in forward motion—

Front, $^7/_{16}'' - ^1/_4''$ lead $= ^3/_{16}''$ error
Back, $^1/_4''$ lead $- ^1/_{16}'' = ^3/_{16}''$ error

To square the lead, the valve must be moved $^3/_{16}''$ ahead.

Error in backward motion—

Front, $^1/_4''$ lead $- ^3/_{16}'' = ^1/_{16}''$ error
Back, $^5/_{16}'' - ^1/_4''$ lead $= ^1/_{16}''$ error

To square the lead, the valve must be moved $^1/_{16}''$ back.

As the errors in the two motions occur in opposite directions, it follows that they augment each other, and that the combined or average error will be the sum of the two, viz.: three-sixteenths of an inch plus one-sixteenth inch equals one-quarter inch average error.

16. To divide this error equally about a central point it will be necessary to move the valve one-half the amount, or one-eighth inch (in this case one-eighth inch ahead in forward motion).

According to rule No. 3, the eccentric rod must be lengthened one-quarter inch (in the proportion of two

to one) to move the valve one-eighth inch. When this has been done, the valve stem will tram as shown in Figure 24.

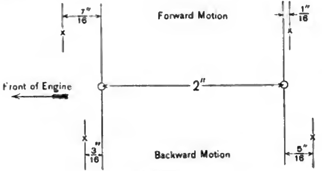


FIG. 23

17. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is one-sixteenth inch too far back to equalize the lead, viz.:

$\frac{5}{16}'' - \frac{1}{4}''$ lead $= \frac{1}{16}''$ error front.

$\frac{1}{4}''$ lead $- \frac{3}{16}'' = \frac{1}{16}''$ error back.

18. To move the valve ahead one-sixteenth inch the link radius rod must be lengthened one-sixteenth inch (see rules 6 and 7) and the lead will then be squared.

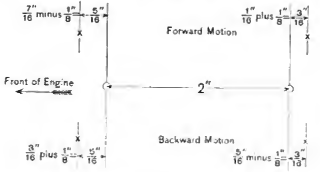


FIG. 24

When trammed for lead, the results will be as shown by Figure 22. These dimensions are the ones required by the specification.

19. The lead has been squared and the errors in Hypothetical Case No. 2 have been corrected by the changes noted below:

Eccentric rod lengthened $\frac{1}{4}''$

Link radius rod lengthened 1/16″

20. Trial of the valve travel and cut-off, etc., can now be made in the manner previously described.

From the above it is evident that the errors in forward and backward motion are equalized by changing the length of the eccentric rod; and the lead is then squared by changing the length of the radius rod. Theoretically the length of the radius rod should be the same as the radius of the link, but as this may vary to a slight extent without any appreciable difference in the valve movement, it is customary to adjust the valve by altering the radius rod unless provision is made for this adjustment on the valve stem.

Setting of Inside Admission Piston Valves

The method of setting inside admission piston valves is generally similar to that previously described. It must be remembered, however, that to perform corresponding functions, this valve moves in a direction opposite to that of the slide valve. When setting piston valves,

FIG. 25

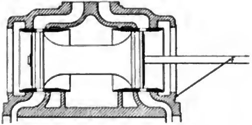


FIG. 26

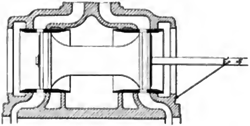
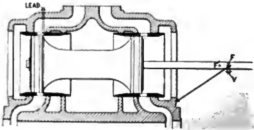


FIG. 27



the steam chest heads should be removed, for the sake of convenience. The line and line positions of the valve are determined by observation through peep holes provided for the purpose. In this way, the points F and F′ are located on the valve stem, by tramming from any convenient point on the back wall of the steam chest. (Figures 25 and 26). The lead points on the valve stem can thus be obtained by placing the crank on the dead centers, and again tramming from the steam chest wall. (Figure 27). The test for lead is made as described in paragraph 2 on page 16, the combining lever occupying positions as shown in Figure 28.

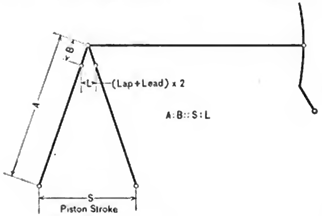


FIG. 28

The lead in full gear, with this style of valve, is examined precisely as described in paragraphs 3 to 7, pages 16 and 17. Reference should be made to Figures 25 and 26, instead of to Figures 15 and 16.

Corrections

As in the case of the slide valve, methods used for correcting errors can be best explained by two hypothetical cases. For example, suppose the specification of a locomotive having inside admission piston valves, calls for the following:

Maximum valve travel, $5\frac{3}{4}$"

Eccentric crank throw, $15\frac{1}{2}$"

Constant lead, $\frac{1}{4}$"

Steam lap of valve, 1"

Link block below link center in forward gear.

The influence of eccentric rod changes on the direction (ahead or back) of the movement of the valve, is explained by reference to Figure 29. An examination

of this figure will show that if the eccentric rod E is lengthened to E′, then the radius rod R will be moved ahead to the position R′, and the valve stem will be moved a distance X in the direction of the arrow, thus displacing the valve from position V to position V′.

If the eccentric rod is shortened, the valve is moved back.

In backward motion—

If the eccentric rod is lengthened, the valve is moved back.

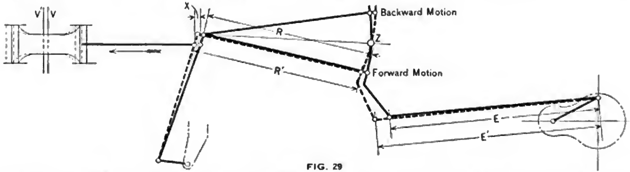


FIG. 29

Therefore, the rules applying in the case of outside admission slide valves also apply to this style of valve, as follows:

In forward motion—

If the eccentric rod is lengthened, the valve is moved ahead.

If the eccentric rod is shortened, the valve is moved ahead.

If the link block is above the center when running ahead, then, in each case, the valve will be moved in the direction opposite to that stated above.

In any case, regardless of whether the gear is in forward or backward motion—

To move the valve ahead, lengthen the radius rod the amount desired.

To move the valve back, shorten the radius rod the amount desired.

It must be remembered that with an inside admission valve, the front port opening is increased if the valve is moved ahead, and the rear port opening is increased if the valve is moved back.

Bearing these facts in mind, two hypothetical cases will now be considered.

Hypothetical Case No. 1

Let it be assumed that, on tramming to the valve stem with the main crank on the dead centers, the following irregularities in the lead are noticed for the engine under consideration. The dots on the diagram represent the prick punch marks F and F' (see Figure 26) on the valve stem, while the crosses represent the irregularities in the lead when trammed to the valve stem (see Figure 20). These irregularities are the same as those used in the corresponding case for slide valves, therefore the same diagrams are referred to. In the present case, however, as the valve is arranged for inside admission, the lead marks for the front steam port will appear on the back end of the valve stem, and those for the back steam port on the front end. A reference to figures 25, 26 and 27 will make this clear. In other words, when applying figures 20-24 to a locomotive with inside admission valves, the front of the engine should be considered on the right instead of on the left. The terms "front" and "back" in the text apply to the steam ports, and not to the positions of the marks on the valve stem.

1. The first procedure will be to divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, $3/8'' - 1/4''$ lead $= 1/8''$ error Back, $1/4''$ lead $- 1/8'' = 1/8''$ error	To square the lead, the valve must be moved $1/8''$ back.

Error in backward motion—

Front, $7/16'' - 1/4''$ lead $= 3/16''$ error Back, $1/4''$ lead $- 1/16'' = 3/16''$ error	To square the lead, the valve must be moved $3/16''$ back.

As the errors in the two motions occur in the same direction, it follows that the greater one partially neutralizes the effect of the lesser, and that the combined or average error will be the difference between the two, viz.: three-sixteenths of an inch minus one-eighth inch equals one-sixteenth inch average error.

2. To divide an average error of one-sixteenth inch equally about a central point, it will be necessary to move the valve one-half the amount or one-thirty-second inch (in this case, one-thirty-second inch ahead in forward motion).

In the engine now under consideration, the eccentric crank throw is fifteen and one-half inches and the valve travel five and three-quarters inches. Hence the ratio of eccentric throw to valve travel is approximately as two and seven-tenths to one. Therefore, according to rule 3, page 18, the eccentric rod must be lengthened two and seven-tenths times one-thirty-second, or approximately five-sixty-fourths of an inch to move the valve ahead one-thirty-second inch. When this has been done, the valve stem points will tram as shown in Figure 21.

3. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is five-thirty-seconds of an inch too far ahead to equalize the lead, viz.:

$^{13}/_{32}'' - {}^{1}/_{4}''$ lead $= {}^{5}/_{32}''$ error front

$^{1}/_{4}''$ lead $- {}^{3}/_{32}'' = {}^{5}/_{32}''$ error back

As the influence of the radius rod is direct (see rules 6 and 7, page 19), it follows that by shortening the rod five-thirty-seconds of an inch, the valve will be moved back that amount and the lead squared. The valve stem can then be trammed to the dimensions shown in Figure 22. These dimensions are the ones required by the specification.

4. The valve has thus been squared and the errors corrected in Hypothetical Case No. 1, by the changes noted below:

Eccentric rod lengthened $^{5}/_{64}''$

Radius rod shortened $^{5}/_{32}''$

5. A final trial of the valve and cut-off, etc., can now be made in the previously described manner.

Hypothetical Case No. 2

Let it be assumed that on tramming for lead, results are obtained as represented by Figure 23.

6. Divide the error between the forward and backward motions, as follows:

Error in forward motion—

Front, $7/16'' - 1/4''$ lead $= 3/16''$ error Back, $1/4''$ lead $- 1/16'' = 3/16''$ error	To square the lead, the valve must be moved $3/16''$ back.

Error in backward motion —

Front, $1/4''$ lead $- 3/16'' = 1/16''$ error Back, $5/16'' - 1/4''$ lead $= 1/16''$ error	To square the lead, the valve must be moved $1/16''$ ahead.

As the errors in the two motions occur in opposite directions they augment each other, and the combined or average error will be the sum of the two, viz.: three-sixteenths of an inch plus one-sixteenth inch equals one-quarter inch average error.

7. To divide the error equally about a central point, it will be necessary to move the valve one-half the amount, or one-eighth inch (in this case one-eighth inch back in forward motion).

According to rule No. 3, page 18, the eccentric rod must be shortened two and seven-tenths times one-eighth inch, or approximately eleven-thirty-seconds of an inch, to move the valve one-eighth inch. When this has been done, the valve will tram as shown in Figure 24.

8. The errors in forward and backward motion have thus been equalized, and it remains only to square the lead front and back for both motions. The valve as now standing is one-sixteenth inch too far front to equalize the lead, viz.:

$5/16'' - 1/4''$ lead $= 1/16''$ error front.

$1/4''$ lead $- 3/16'' = 1/16''$ error back.

9. To move the valve back one-sixteenth inch, the link radius rod must be shortened one-sixteenth inch (see rules 6 and 7, page 19), and the lead will then be squared. When trammed for lead, the results

will be as shown in Figure 22. These dimensions are the ones required by the specification.

10. The lead has been squared and the errors in Hypothetical Case No. 2 have been corrected by the changes noted below:

Eccentric rod shortened $^{11}/_{32}$"

Link radius rod shortened $^{1}/_{16}$"

11. Trial of the valve travel and cut-off, etc., can now be made in the manner previously described.

12. It will be noticed in the two cases given that the lead was $^{1}/_{4}$" after squaring in both forward and backward motions, but cases may be found where the lead is greater in one motion than in the other, due to the eccentric crank being of incorrect length or improperly located. As mentioned on page 6, the crank should be set so that link will be in the same position when the piston is at either end of the stroke, and if this is not correct on the engine, the crank should be changed by altering its length or moving it radially on main crank pin.

Setting of Outside Admission Piston Valves

With valves of this type, the arrangement of the gear is the same as that used with outside admission slide valves, and the method of setting is the same. The line and line positions of the valve, however, must be observed through peep holes, as in the case of the inside admission piston valve.

Breakdowns

The handling of the Walschaerts gear in the event of a breakdown presents no special difficulties. It is usually desirable, if possible, to take down both the eccentric rod and main rod. The cross head and valve stem can then be securely blocked, exactly as in the case of an engine equipped with the Stephenson gear. The radius rod should be disconnected from the reverse shaft by removing the lifting link. If the valve is blocked in its middle position, the cylinder on the damaged side will be cut out.

If the main rod, crosshead and piston on the damaged side are in a condition to run, the main rod may be left up, provided there are relief valves in the cylinder heads. The relief valves should be removed, so that the cylinder can be lubricated and excessive compression avoided. With the eccentric rod down, and the valve securely blocked in its middle position, the engine can then be run with the other side. It is of course necessary, in this case, to remove the crosshead link, and fasten the combining lever in forward position. The foot of the lever can readily be secured to one of the cylinder cocks.

If the damage is confined to the eccentric crank or rod, or to the lower end of the link, and the latter is still supported on its trunnions, the main rod may be left up, and the valve operated by the combining lever. To accomplish this, take down the eccentric rod, disconnect the radius rod from the reverse shaft, and secure the link-block exactly at the center of the link. The maximum port opening on the damaged side will now be equal to the lead, and the cut-off will be very short; but the steam will do at least some work, and the engine can be reversed and both the cylinders lubricated.

Reproducing Model of the Walschaerts Valve Gear

Figure 30 shows a full size model used by The Baldwin Locomotive Works for reproducing the motion of the Walschaerts valve gear, applied to locomotives. On this model can be measured all the valve events, such as travel, lead, cut-off, release, etc., in both forward and backward motions; and any relative position of the valve to the piston can be found. This machine has adjustable parts which may be made to conform to the length of the actual parts on the locomotive, and arranged in the same relative location.

To obtain the motion the machine is driven at the wheel by an electric motor, or revolved by hand to suit the operator.

The valve events may be permanently recorded on

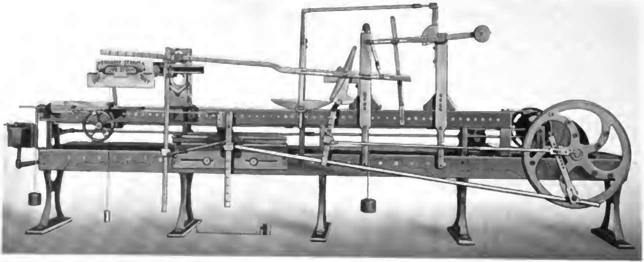


FIG. 30

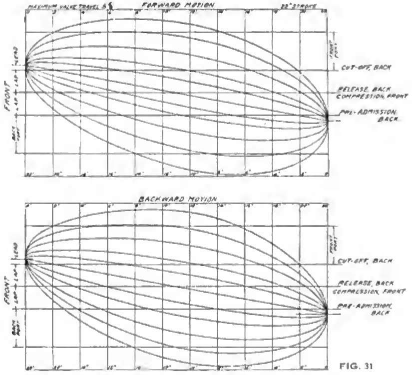

FORWARD MOTION
CUT-OFF, BACK
RELEASE, BACK
COMPRESSION, FRONT
PRE-ADMISSION, BACK
FRONT
BACKWARD MOTION
CUT-OFF, BACK
RELEASE, BACK
COMPRESSION, FRONT
PRE-ADMISSION, BACK
FRONT

FIG. 31

paper or tracing cloth by a pencil moving across a cylinder attached to the machine. This cylinder rotates at the same speed as the valve movement, and the pencil travels lengthwise of the cylinder at one-half the piston speed, producing an ellipse similar to those shown in Figure 31. The horizontal length of the diagram represents the stroke of the piston, while the distance moved by the valve is measured vertically. The central line in each group of ellipses represents the movement of the valve when operating in mid-gear; the outside ellipse represents the movement in full gear, while the intermediate ellipses represent the movement when the gear is hooked up for various points of cut-off. By following a complete ellipse, the exact location of the valve can be found for every point in the piston stroke and the positions of the piston at which the various valve events occur can be accurately determined.

The operation of the machine, including the drawing of the ellipses, has been recorded in moving pictures.

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